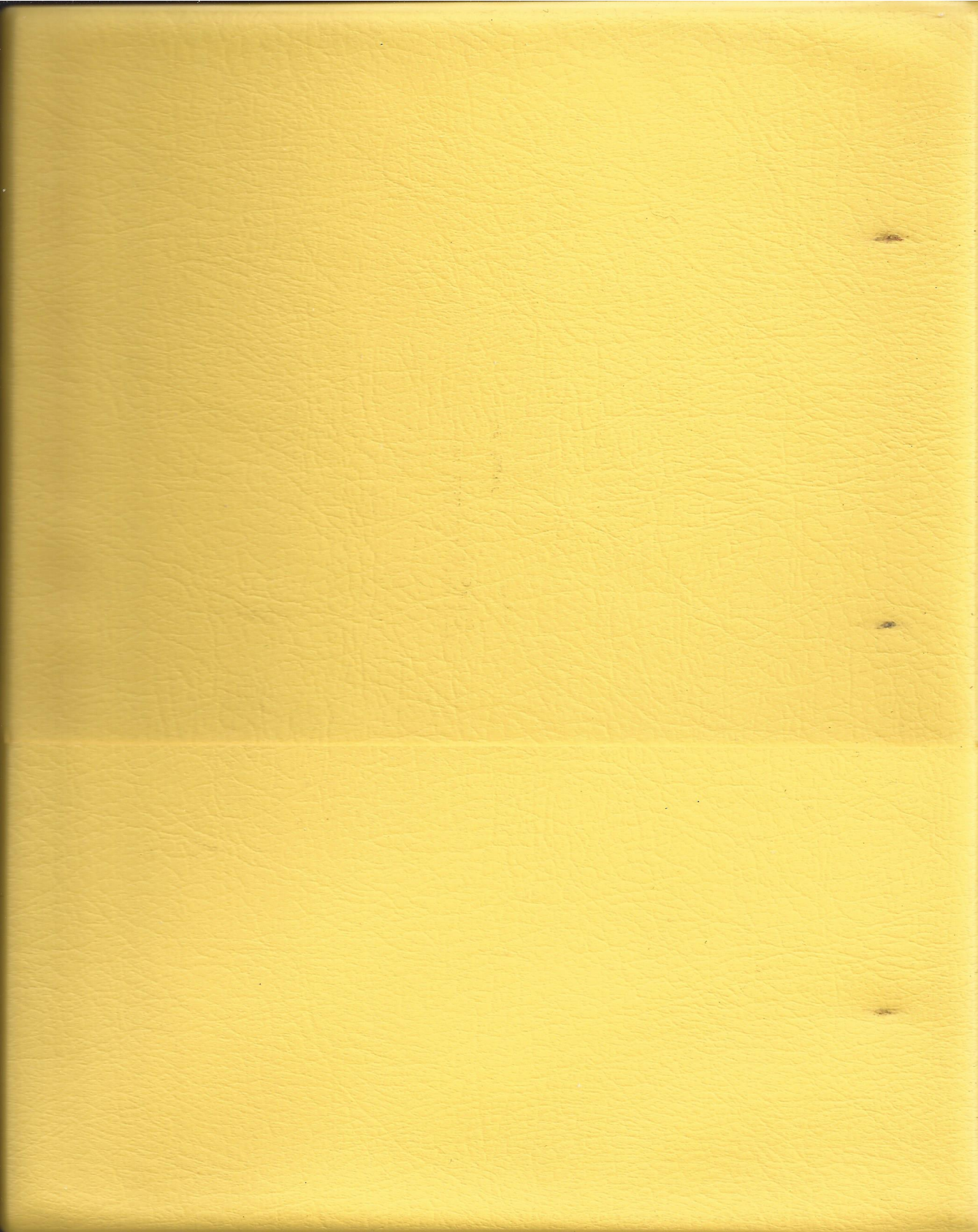# Action!™

A Language For
Your ATARI® Computer

OSS™ Precision Software Tools

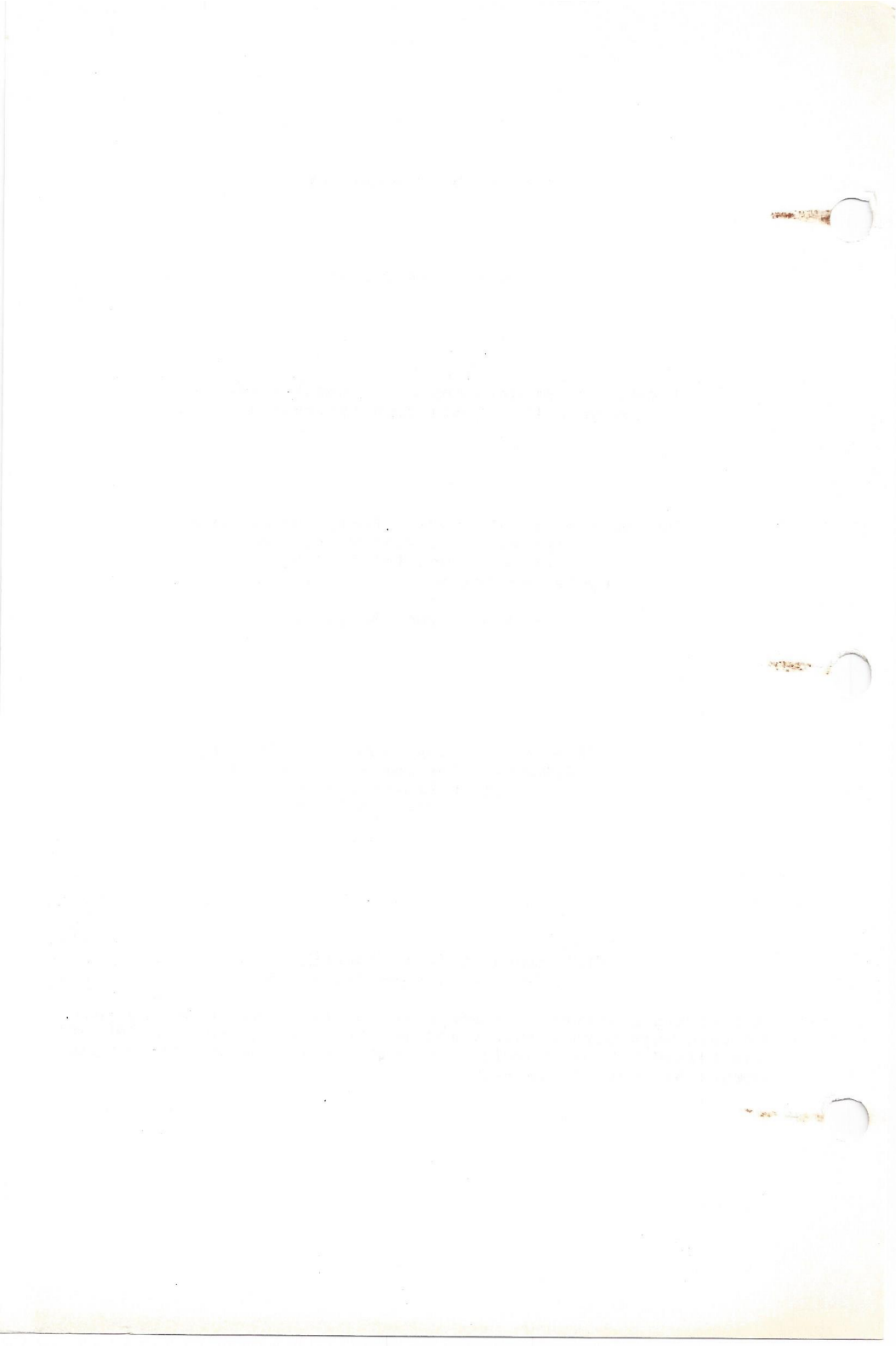a reference manual for

The ACTION! System

A complete programming enviornment designed
for your Atari home computer system.

The programs, cartridges, ROMs, and manuals
comprising the ACTION! system
are Copyright (c) 1983 by
Optimized Systems Software, Inc.
and
Action Computer Services

This manual written August, 1983

THE ACTION! SYSTEM

PART I: Introduction to ACTION!

PART II: The ACTION! Editor

PART III: The ACTION! Monitor

PART IV: The ACTION! Language

PART V: The ACTION! Compiler

PART VI: The ACTION! Library

APPENDICES

Part I: Introduction to ACTION!

Welcome to ACTION! We're here to introduce you to a
complete software development system - one in which you
can perform all of your programming tasks.

If you have programmed your Atari using Atari BASIC,
you will discover that ACTION! runs a lot faster, has
a better editor, and is just as easy to learn.

If you have ever done assembly language programming,
you will find that ACTION! is almost as fast as
assembly language, as far as program execution is
concerned. You will also find that programming ACTION!
is much quicker and easier due to the nature of the
language, its editor, and its library of routines.

For those of you with very little or no previous
programming experience, we suggest that you read this
manual very carefully, and be sure you understand one
concept before moving on to the next. We say this
because this is not a tutorial to teach you the ACTION!
system, but rather a reference manual of all the
capabilities of the system.

That is not to say that you won't understand what
you're reading (quite the contrary); it simply means
that we don't discuss every possible programming use of
the concepts involved. We respect your ingenuity and
curiosity and believe that you yourself will find some
uses we haven't even dreamt of.

Notes On This Manual

The manual itself is separated into six parts and a
group of appendices. Each of the parts exclusively
discusses one facet of the ACTION! system, thus
enabling you to learn about the different components of
ACTION! without having to keep flipping pages. Each
part is prefaced by a table of contents, an
introduction, and a vocabulary.

The one drawback to separating the ACTION! system into
its component parts is that you will learn everything
about one part before starting the next part. To help
alleviate this problem we suggest that you read the
introduction section of each of the parts before
reading one part in depth. Also, the last chapter of
this introduction shows you how the ACTION! components
work together to allow you to run programs.

Chapter 1: The ACTION! System

The ACTION! system is made up of five different parts:

                The ACTION! Monitor
                The ACTION! Editor
                The ACTION! Language
                The ACTION! Compiler
                The ACTION! Library

The Monitor is the boss of the ACTION! system.
Through it you can call the Editor, the Compiler, or
get access to some system options. This is the
monitor's only job, but it is a important one, allowing
you to decide which part of the ACTION! system you want
to use at any given time.

The Editor is where you create new programs and modify
old ones. It doesn't know anything about the ACTION!
language or compiler (that is, it's simply a text
editor and doesn't check language syntax), so you can
use it for other word processing or program entry
applications. The Editor also allows you to save the
text in the editor buffer or read text from a
peripheral device (disk drive, cassette, etc.) into
the editor buffer.

The ACTION! Language is what you use to communicate
with the ATARI machine and tell it to do things. You
write a program in the ACTION! Language, and then tell
the ACTION! Compiler to translate it into a form the
computer can understand (machine language), and then
you run the program.

"Why such an involved process? BASIC isn't like that."
First of all, the process isn't that involved once you
understand what's going on and why. Secondly, BASIC
isn't like that because it is an Interpreter, not a
Compiler. BASIC translates each line as the program is
running, and it takes some time to do that, thereby
slowing down the speed of your program. ACTION!, on
the other hand, breaks the running and syntax checking
of your program into two parts. The Compiler checks
your program for proper syntax, and does the
translating. When it is through, your program can be
run directly, i.e., without any syntax checking. This
makes your program run with incredible speed.

As mentioned in the previous paragraphs, the ACTION!
Compiler translates an ACTION! program into machine

code. The only thing it requires is that the program be in proper ACTION! form. The compiler will give you an error if you use syntax which is illegal in the ACTION! Language, just like an English teacher would give you an error (or red mark) if you used improper English in class.

The ACTION! system also contains a group of prewritten routines which you can use in your programs. This group of routines is called the ACTION! Library, and it enables you to do all the things you can do in BASIC (i.e., PLOT, DRAWTO, PRINT, etc.) and much more without writing any special subroutines of your own.

TECHNICAL NOTE: although the ACTION! compiler does translate an ACTION! to 6502 machine language, that compiled code will not run without the ACTION! cartridge because it (the code) does some calls to routines in the cartridge. If you are writing products for resale, a runtime version of ACTION! which will make your program work without the cartridge can be licensed from OSS Inc.

Chapter 2: How To Write and Run an ACTION! Program

This chapter is designed to let you "get your feet wet"
and become more familar with the ACTION! system.
We're going to write a little program in the Editor,
Compile that program, and Run it.

When you go to the cartridge from DOS you will be in
the ACTION! Editor, so the program can be entered
immediately. We're going to assume that you won't make
any typos, but if you do, you can use the cursor
control keys (<CTRL><up arrow>, etc.) to move around
and fix them. When you read the Editor part you will
find out about many more editor featues and commands,
but these are all you need for this program.

Now for the program. Enter it exactly as you see it
here (no special commands are required to enter text):

    PROC hello()

        PrintE("Hello World")

    RETURN

Before we compile this program, let's discuss what's
going on. The 'PROC' and 'RETURN' statements are
required by the ACTION! language, and make up the
bones of a procedure. The language is structured into
a group of subroutines called procedures and functions,
with each routine doing a specific task which you
define. This might seem strange at first, but it
allows you to write programs in components so that you
can concentrate on one part of the program at a time.
It also makes programs written by others much easier to
read.

The above procedure is called "hello", namely because
it will print out the line "Hello World" to the screen
when the program is run.

The statement starting with 'PrintE' is a library
routine call. Here we are making use of one of the
prewritten routines in the ACTION! library. This one
will print out the specified string, and put out a
<RETURN> at the end. This routine call is the only
statement in the procedure 'hello' (because it is the
only statement between the 'PROC' and 'RETURN').

Now that we have the program in the Editor buffer, how
are we going to compile and run it? The Editor
certainly can't do it for us, so we need to get to the

Monitor and call the ACTION! Compiler from there. The
Editor command <CTRL><SHIFT>M takes us to the Monitor,
so we'll use that.

Now that we're in the Monitor, we need to call the
Compiler to check the syntax of our program and
translate it into machine language. This is done by
typing the command 'COMPILE <RETURN>' to the Monitor.

The compiler takes over and does its job. If it finds
an error, it will print out an error message and return
you to the monitor. If it finds no errors, the
Compiler will return us to the Monitor. From there we
can run the compiled program by entering the command
'RUN <RETURN>'. The screen should look like this after
you've run the program:

```
        +-------------------------------------------+
        |  >                                        |
        +-------------------------------------------+
        |  Hello World                              |
        |                                           |
        |                                           |
        |                                           |
        |                                           |
        |                                           |
        |                                           |
        |                                           |
        |                                           |
        +-------------------------------------------+
```

You have written your first ACTION! program!

If you got an error message from the compiler, it means
that you didn't type the program in properly. You can
go back to the Editor from the Monitor by typing
'EDITOR', and can fix your typo. You might note that
the cursor is placed at the position where the compiler
found the error, so you don't have to look all over for
it. Repeat the steps discussed above to re-compile and
re-run your program after you've fixed the error.

NOTE: there is a list of the error codes with their
meanings in appendix C.

Part II: The ACTION! Editor

Part II: The ACTION! Editor

Chapter 1: Introduction

The Editor is where you create new ACTION! programs
and edit old ones. If you have used a program editor
before, you will notice that the ACTION! Editor is far
more sophisticated than most others: in fact, it could
almost be called a word processor because it does so
much.

Although it is capable of many things, you will find
that the ACTION! Editor is easy to work with. If you
have never been exposed to anything but the Atari
screen editor, then you are in for a pleasant surprise.
You can use the ACTION! Editor for any editing you
want to do, not just editing ACTION! programs. You
could do all your editing (correspondence, programs in
other languages, etc.).

1.1 Special Notations and Vocabulary

USAGE OF SINGLE QUOTE MARKS (')

Unless format and context make the use of quotes
unnecessary, commands and special characters will be
enclosed in single quotes.

USAGE OF '<' AND '>'

When talking about a key on the Atari keyboard, we will
enclose it with the characters '<' and '>', thus:

        <BACK S> (the backspace key)

Some of the keys have more than one label written on
them. In these cases, the label best describing the
Editor command will be used.

There is one exception to the above; the character (A -
Z) and digit (Ø - 9) keys are not enclosed by the angle
brackets.

MULTI-KEYSTROKE COMMANDS

Some of the Editor commands require that you press more
than one key at a time. For these commands, the keys
required are given back to back in the order in which
you should press them. For example,

        <SHIFT><DELETE>

means that you should hold the key marked 'SHIFT' down,
and then press the key marked 'DELETE'.

THE MESSAGE AREA

Throughout this part of the manual the term "message
area" will be used. This area is simply the inverse
video line you will notice at the bottom of your screen
when you enter the Editor. This line normally has

        ACTION! (c)1983 ACS

written on it, but is used by some of the editor
commands to ask you questions, give you information, or
report an error.

When you are using two windows (see section 3.4), the
message area line separates the two windows.

DEFAULT USER RESPONSE

Some of the commands which use the message area to
exchange information with you remember the information
you gave the last time you used the command. This
information is called the "default user response". If
the default user response you see in the message area
is what you want, you simply press <RETURN>. This
saves you time because you don't have to retype the
same response many times. If you don't want to use the
default user response, you have the ability to change
either part or all of it.

1.2 Editor Concepts and Features

TEXT WINDOWS

When you look at your TV or monitor screen, imagine
that you are looking through a window. At any one time
you can only see 23 lines of 38 characters each. This
seems very limiting, and would be if you couldn't move
the window around. The ACTION! Editor makes it
possible for you to move this window around, both
horizontally and vertically, so that you can look at
you whole program.

But the Editor is even more sophisticated than that!
If you are looking through the window, and you want to
look at one line which extends beyond the bounds of the
window, you can move to that line and look at the whole
thing. The line will move to fit into the window, but
the window stays right where it was. When you move off
that line, it pops back into its proper place (with
respect to the window).

The Editor evens allows you to split your screen into
two windows, each of which you can control separately.
This enables you to look at two different programs, or
different parts of the same program, at the same time.

TEXT LINES

The ACTION! Editor is designed so that your program
can be read easily. It allows lines up to 240
characters long (even though the window only shows 38
characters at a time), so you can use indentation to
clarify your program without worrying about making
lines too long. The Editor also allows blank lines, so
you can separate the components of your program with
white space.

NOTE: you also have control over the maximum line
length, so you pick a line length you think best (or
will fit on your printer). The Editor even buzzes when
you reach the limit, to let you know it's time to go to
the next line.

NOTE: if a text line is longer than the window (if it
extends beyond the left or right bounds of the window),
the character at the edge of the window is shown in
inverse video to make you aware of this.

FIND and SUBSTITUTE

The Editor allows you to search for a given string, and will move the cursor to the first match found in the program.

The Editor also allows an extension of this. You can tell it to search for a given string, and then replace the first match with another string you specify, all with one command.

MOVING TEXT BLOCKS

Have you ever entered a program and wished that a group of lines which you entered at one location could be conveniently moved to another location? In ACTION, this is a snap!

Saving those lines (called a text block) in the copy buffer (that's where a text block is temporarily saved) allows you to move the cursor to where you want the text block placed. You may then "paste" the contents of the copy buffer (the lines you wanted to move) back into the program. You can paste the text block at its original location, and then move somewhere else and paste it there too, thus enabling you to copy text blocks.

CURSOR MOVEMENT

The cursor is controlled not only by the movement keys on the keyboard (e.g., <CTRL><up arrow>), but can also be made to move to a specified places places in your text through the use of tags and the 'FIND' command.

TAGS

You can mark any location in your text with an invisible marker called a "tag". The Editor allows you to move the cursor to this tag (no matter where the cursor was before) through the use of a simple command.

The number of tags you allowed is limited only to the number of keys on the keyboard, since you must give a one character label to each tag you define.

Chapter 2: The Editor Commands

This chapter is devoted to the Editor commands
themselves. Instead of presenting the commands in this
form:

        2.2 <CTRL><SHIFT>M
        ----

where you can't tell what the section discusses (unless
you already know the Editor), the commands are
presented by their function, e.g.:

        2.2 Leaving the Editor

We hope this form makes things clearer and easier to
follow.

Before going into the commands themselves, we should
tell you how to stop execution of a command if you made
a mistake. You can do this by pressing the <ESC> key.
Doing this will get you out of any command safely.

NOTE: appendix E provides a summary of the Editor
commands, listed by the command itself instead of what
it does.

2.1 Getting to the Editor

When you first enter the ACTION! system, you will
automatically be put into the Editor, so there is
nothing involved in "getting to" it. You're already
there.

If you leave the ACTION! system and go to DOS (OS/A+,
DOS XL, or Atari DOS), you will be in the Monitor when
you re-enter ACTION! (there is one execption to this;
see NOTE below). To get to the Editor from the
Monitor, you need only type

        E<RETURN>

This will put you directly into the editor.

NOTE: if you are using OS/A+ or DOS XL, and you execute
a DOS extrinsic command before returning to the ACTION!
system, you will not be put into Monitor as stated
above, but straight into the Editor. This is not the
case with Atari DOS, since it has no extrinsic
commands.

2.2 Leaving the Editor

There is only one way to leave the Editor (aside from turning off the computer):

        <CTRL><SHIFT>M

This command will cause you to go from the Editor to the Monitor, where you may call the other components of the ACTION! system or leave the system altogether and go to DOS.

2.3 Text Entry

There is no special Editor command to allow you to enter text. You simply type it in, as on a typewriter. When you have reached the maximum line length, the Editor will buzz everytime you put in another character (see 2.3.2 for more information).

If you want to type a control character, you must press the <ESC> before doing so. This lets the Editor know that the control character should be interpreted as text, and not as an Editor command.

"What happens when I try to type over something I've already written?" The ACTION! Editor allows you two options in this case. Text can be entered in either "Replace" or "Insert" mode.

When in Replace mode, the text you enter will overwrite whatever was there before, replacing the old with the new character by character.

When in Insert mode, the text you enter will be inserted wherever the cursor is, and move all the previous text over without overwriting it.

The Editor command <CRTL><SHIFT>I allows you to change from one mode to another. When you use this command, the mode you have changed to will be printed in the message area (see section 2.5.2 for more information).

NOTE: the Editor is in Replace mode when you first enter it.

If you want to erase all the text in a file, just put the cursor into the window you want to clear, and press <SHIFT><CLEAR>. This will clear not only what you see in the window, but the entire file (see section 2.6.4 for more information).

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2.3.1 Text File I/O

If there were no way to save the program in the Editor buffer, you would have to retype it every time you wanted to use it. The Editor allows you both to read and to write files to any peripheral storage device (Disk Drive, Cassette, etc.) to save you all this trouble.

To save a program in the Editor buffer, you must first put the cursor into the window which contains the file you want saved (if you are using only one window, you needn't worry about this). Then you enter the command

<CTRL><SHIFT>W

In the message area you will see:

Write?

Simply type in the file name you want the program saved to, and press <RETURN>. The file name must be compatible with the DOS you are using. If you are not using a DOS, the file will consist only of a character representing the device (C for cassette, P for printer, etc.) followed by a colon.

Reading a file into the Editor buffer is just as easy. Move the cursor to the line preceeding the line where you want the file you're reading in to start, and enter the command

<CTRL><SHIFT>R

In the message area you will see:

Read?

Type in the name of the file you want read in, following the conventions outlined above.

If you are using floppy disks, you can read the directory on a given disk by replying with the following to the "Read?" prompt in the message area:

Read? ?1:*.*

This will read the directory of the disk in drive number 1. If you want to read the directory of a disk in some other drive, simply change the '1' in the above example to the number of the drive. This ability is very useful, because you needn't go to DOS to find out what's on a disk.

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2.3.2 Setting the Line Length

As mentioned in the first paragraph of section 2.3, you can set the maximum line length. You can find out how to do this in part III, section 2.5, so we need not show you here.

2.4 Cursor Movement

To move the cursor left one character, press:

        <CTRL><left arrow>

To move the cursor right one character, press:

        <CTRL><right arrow>

To move the cursor up one line, press:

        <CTRL><up arrow>

To move the cursor down one line, press:

        <CTRL><down arrow>

The   commands above   are simply the normal cursor movement keys the Atari screen editor understands. The ACTION! Editor, however, allows you some more cursor movement commands designed to increase your program writing speed.

You can make the cursor go to the beginning of the line its on by pressing:

        <CTRL><SHIFT><

and go to the end of the line by pressing:

        <CTRL><SHIFT>>

These two commands will take you to the true beginning or end of the line even if it (the beginning or end) is not visible in the window. The line will simply be shifted over so that it (again, the beginning or end) is visible in the window. When you move the cursor off the shifted line, the line will be moved back to its proper position.

You can go to the beginning of the file by pressing:

        <CTRL><SHIFT>H

2.4.1 Tabs

You can move the cursor to the next tab stop by pressing <TAB>.

To set a tab stop, move the cursor where you want the tab, and then press <SHIFT><SET TAB>.

To clear a tab stop, move to the tab stop you want cleared, and press <CTRL><CLR TAB>.

2.4.2 Finding Text

The Editor allows you to "find" a specified string of characters (1 - 32), and can be very useful when skipping from place to place in your file. To do this enter the command:

        <CTRL><SHIFT>F

The message area will prompt you with

        Find?

If you have previously used the Find command, you will see the string you last tried to find following the prompt. If you want to find the next occurance of this string, simply press <RETURN>. If you want to find a different string, type in the new string and press <RETURN>. You will notice that the old string disappears as soon as you start typing.

If this is the first time you are using the Find, you will see nothing following the prompt, and you should type in the string you want found and press <RETURN>.

This command will start at the current cursor position and look for the first occurance of the string you specified. If the string is found, the Editor will move the cursor to the first character in the found string and make the window move to display the surrounding section of text. If the string isn't found, the message area will display the line:

        not found

2.5 Correcting Text

The following six sections will give you information on
how to correct and delete text from the Editor buffer.
The seventh sections shows you how to undo certain
deletions if you have made a mistake.

2.5.1 Deleting a Character

To delete the character under the cursor (the one the
cursor is flashing on top of), press:

        <CTRL><DELETE>

The characters to the right of the character just
deleted will move left to fill the empty space left by
the deleted character.

To delete the character to the left of the cursor,
press:

        <BACK S>

If you are in Replace mode, this will replace the
character to the left of the cursor with a space.   If
you are in Insert mode, this will delete the character
to the left of the cursor, and then move all the
following characters over to fill the empty space.

2.5.2 Inserting/Changing a Character

As mentioned in section 2.3, there are two different
modes for text entry: Replace mode and Insert mode.
When you first enter the ACTION! Editor, it is in
Replace mode.   To change from one mode to the other,
press:

        <CTRL><SHIFT>I

Some of the Editor commands are mode dependent; that
is, they operate differently, depending on the text
entry mode.

You can insert a blank character at the cursor position
by entering <CTRL><INSERT>. The text from the cursor
to the right end of the line moves right one space and
a blank space is inserted at the cursor position.

NOTE: if you are in Insert mode, you can simply press
the space bar.

2.5.3 Line Deletions

To delete a whole line, place the cursor on the line
you want deleted, and press:

        <SHIFT><DELETE>

The succeeding lines move up to fill the empty space.

3.3.4 Line Insertions

To insert a blank line above the line the cursor is on,
press:

        <SHIFT><INSERT>

The succeeding lines move down to allow space for the
new blank line.

3.3.5 Breaking & Recombining Lines

To break a single line into two adjacent lines, first
position the cursor on the character you want as the
first character in the second line, and then press:

        <CTRL><SHIFT><RETURN>

NOTE: if you are in Insert mode, simply position the
cursor and press <RETURN>.

Succeeding lines of text are moved down to allow room
for the new line.

To combine two adjacent lines into a single line, first
position the cursor on the first character in the
second line, and then press:

        <CTRL><SHIFT><BACK S>

Succeeding lines are moved up to fill the empty space.

2.5.6 Substituting Text

The ACTION! Editor allows you to substitute a "new"
string for an "old" one. You are prompted for the
"new" string, and then for the "old" one. The Editor
searches for the first occurance of the "old" string
(starting at the cursor position), and replaces it with

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the "new" string. To begin this command, press:

 <CTRL><SHIFT>S

The message area will display the prompt:

 Substitute?

If you have previously used this command, you will see
the last "new" string you used following the prompt.
If you want to keep this "new" string, simply press
<RETURN>. If you want a different "new" string, type
it in and press <RETURN>.

If this is the first time you are using Substitute, you
will see nothing following the prompt, and you should
type in the "new" string you want and press <RETURN>.

After you press the <RETURN>, the message area will
prompt you with:

 for?

You will see the last "old" string you used following
this prompt if you have used the Substitute before. If
you want to keep this "old" string, simply press
<RETURN>. If you want a different "old" string, type
it in and then press <RETURN>.

If this is the first time you are using Substitute, you
will see nothing following the prompt, and you should
type in the "old" string you want changed and press
<RETURN>.

After you press this second <RETURN>, the Editor will
try and do the substitution. If it can't find the
"old" string you've given, the message area will show
the following:

 not found

If you press <CTRL><SHIFT>S again before you do any
other editing, the Editor will execute the same
substitution. This enables you to substitute
more than one occurance of the "old" string with the
"new" one without having to keep reponding to the
"Substitute?" and "for?" prompts.

HINT: you can delete the next occurance of a string by
using this command with the "new" string being nothing.
This with substitute the "old" string with nothing, and
so (in effect) delete it.

2.5.7 Restoring a Changed Line

The ACTION! Editor allows you to restore a line to its previous form if you have made an error while editing it. To do this, you must remain on the changed line and press:

        <CTRL><SHIFT>U

WARNING: if you leave the line and then come back to it, this command will not work, because the Editor only remembers what the line was before you started editing it while you remain on the line.

If you have accidentally deleted a whole line, you can retrieve it by pressing:

        <CTRL><SHIFT>P

More information about this command may be found in section 2.7.

NOTE: the tags on the changed or deleted line are not restored.

2.6 Windows

The displayed contents of the central portion of the screen is called a window. The following five sections describe the Editor commands used to manipulate, create, and delete windows. In these sections we use the term "current window" to mean the window which the cursor is in.

2.6.1 Window Movement

You can make the window scroll up or down one line simply by moving the cursor. If you try and move the cursor off the top of the screen, the window moves up one line to keep the cursor on the screen. The same works with the bottom of the screen. This type of vertical scrolling could take a long time if your program were big, so the Editor also allows you to make the window scroll by the size of the window itself.

To move up one window, press:

        <CTRL><SHIFT><up arrow>

For the sake of continuity, what was the top line in

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the old window is now the bottom line of the new window.

To move down one window, press:

        <CTRL><SHIFT><down arrow>

For the sake of continuity, what was the bottom line in the old window is now the top line of the new window.

The Editor also allows you to scroll the window horizontally. That is, you can make the window's left margin start at any column (instead of the first column). If a line is longer than the window (if it extends beyond the left or right bounds of the window), the character at the edge of the window is shown in inverse video to make you aware of this.

To move the window one character to the right, press:

        <CTRL><SHIFT>]

To move the window one character to the left, press:

        <CTRL><SHIFT>[

2.6.2 Creating a Second Window

When you first enter the ACTION! Editor there is only one window. You can create a second window by pressing:

        <CTRL><SHIFT>2

The screen will now look like this:

```
+-------------------------------------------+
|                                           |
|                                           |
|                                           |
|                                           |
|                                           |
|                                           |
+-------------------------------------------+
|   ACTION! (c)1983 ACS                     |
+-------------------------------------------+
|                                           |
|                                           |
+-------------------------------------------+
```

The window above the message area is window 1, and the window below it is window 2. You can use each window

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independently, so you could be working on two entirely
different files without having to keep clearing window
1 and reading in a file.

NOTE: the size of the window 1 can be set using the
Options Menu available from the monitor. For more
information on how to do this, see part III, section
2.5.

2.6.3 Moving Between Windows

To move from window 1 to window 2, press:

        <CTRL><SHIFT>2

If window 2 does not yet exist, then the Editor creates
window 2, then moves the cursor into it.

To move from window 2 to window 1, press:

        <CTRL><SHIFT>1

2.6.4 Clearing a Window

To clear the text file in a window, move the cursor
into that window (see previous section), and press:

        <SHIFT><CLEAR>

Since this is such a powerful command, the message area
will prompt you with:

        Clear?

Respond with a "Y" or "N". If you have made changes to
the file viewed through that window, and have not saved
the changed version, the message area will prompt you
with:

        Not saved, Delete?

to make sure that you know that you have not saved the
new version.

WARNING: this command does not simply delete the
portion of the file visible in the window, but rather
deletes the entire file.

3.4.5 Deleting a Window

To delete a window (i.e., make the window itself go
away), first position the cursor in the desired window,
and then press:

        <CTRL><SHIFT>D

In the message area you will see the prompt:

        Delete Window?

Respond with a "Y" or "N". If you have made changes to
the file viewed through that window, and have not saved
the changed version, the message area will prompt you
with:

        Not saved, Delete?

to make sure that you know that you have not saved the
new version.

When you delete a window, the screen space it occupied
is given back to the other window. If you delete
window 1, then window 2 becomes window 1 (since there
is only one window, it must be window 1).

3.5 Moving/Copying Blocks of Text

The ACTION! Editor allows you to move or copy text
blocks through the use of a copy buffer. Whenever you
use the command <SHIFT><DELETE> to delete a text line,
that line is temporarily stored in a region called the
copy buffer. You may then "paste" that deleted line
using <CTRL><SHIFT>P.

The copy buffer is cleared every time you use the
<SHIFT><DELETE>, with one exception. If you use the
<SHIFT><DELETE> consecutively (i.e., without doing any
other commands or text entry between the deletes), the
copy buffer is not cleared. Instead, the second (and
following) deleted lines are also stored in the copy
buffer, thus loading it with a text block.

Now, when you use the <CTRL><SHIFT>P command, the
entire text block in the copy buffer is pasted back
into the text.

Enough of the overview; on to the method itself.

To move a block of text, position the cursor on the

first line of the block, and press <SHIFT><DELETE>
until you have deleted the entire block. Move the
cursor to the line above which you want the block to be
pasted. Now, simply press <CTRL><SHIFT>P, and the
block will be pasted.

To copy a block of text, use the same method as for
moving a block, but first paste the block back into its
original position before moving to place where you want
it copied. Since pasting does not clear the copy
buffer, you can paste the same block (or line) in many
different places, thus allowing multiple "copy"s.

2.8 Tags

Tags allow you to mark any location in your text. To
set a tag at a given cursor position, press:

        <CTRL><SHIFT>T

The message area will display the prompt:

        tag id:

Enter the one character identification you want for
that tag and press <RETURN>. If the id you give
already has a tag associated with it, the old tag will
be lost, and the id will refer to the new tag.

To move to a specified tag, press:

        <CTRL><SHIFT>G

The message area will display the prompt:

        tag id:

Enter the id character of the tag you want to go to.
If the tag exists, the cursor will be moved to it, and
the window will be moved to display the surrounding
text. If the tag doesn't exist, the Editor will print

        tag not set

in the message area. This means that no tag with the
given id character exists.

WARNING: Any operation which alters the contents of the
line (character insertions, deletions, or changes, line
breaking or recombining) clears the tags in the line.

HINT: if you use the digits (Ø - 9) as tag ids, you are
more likely to remember the id character.

3.1 Identical Commands

<SHIFT>

Used in conjunction with letter keys to change the case of the letters or used to enter either an alternate character or command. Hold the <SHIFT> key down while pressing the following key in the sequence (e.g., <SHIFT>_, symbolizing the underline character "_", means that you should hold the <SHIFT> key down while pressing the "_" key).

<CTRL>

Used in conjunction with one or more other keys to communicate a command or special character to the editor. Hold the key down while pressing the following key in the sequence (e.g., <CTRL><up arrow>, symbolizing the command to move the cursor up one line, means that you should hold the <CTRL> key down while pressing the <up arrow> key).

<Atari>

Display succeeding characters in inverse video. Press key a second time to return to normal video display of entered characters.

<ESC>

Allows the following control character to be entered as text.

<LOWR>

Shift letter entry to lower case (like unlocking the shift lock on a regular typewriter).

<SHIFT><CAPS>

Shift letter entry to upper case letters only (like pressing shift and shift lock keys simultaneously on a regular typewriter).

<SHIFT><INSERT>

Inserts a blank line on the line where the cursor is. The line where the cursor was and succeeding text lines are moved down to make room for this line.

<CTRL><INSERT>
    Inserts a blank space where the cursor is.
    Succeeding characters on the same line are moved
    right one character to make room for the inserted
    space.

<CTRL><up arrow>
    Moves cursor up one text line.

<CTRL><down arrow>
    Moves cursor down one text line.

<TAB>
    Move to the next set TAB location, if any. Do not
    move if no additional TAB exists. Inserts spaces
    if no text (or spaces) exist here already.

<SHIFT><SET TAB>
    Establish a TAB location at the current position
    of the cursor.

<CTRL><CLR TAB>
    Clear the TAB, if any, at the current cursor
    location.

3.2 Differing Commands

<BREAK>
    This key is not used by the ACTION! editor.

<SHIFT><CLEAR>
    Clears file in the current window. The editor
    warns you when the file has not been saved since
    the last text modification and allows you to
    cancel the command.

<RETURN>
    In Replace mode, this moves the cursor to the
    beginning of the next line. In Insert mode, it
    inserts a <RETURN> into the text.

<SHIFT><DELETE>
    Removes the line the cursor is on (like Atari
    screen editor). Succeeding lines are moved up to
    replace the deleted line. Can be used repeatedly.
    Removed line(s) is(are) stored in a temporary
    holding area (called the copy buffer) for text
    copy/move processing. See <CTRL><SHIFT>P
    description and section 2.7.

<BACK S>
    If in Replace mode (see <CTRL><SHIFT>I), then this
    replaces the character to the left of the cursor
    with a space. In Insert mode, this removes the
    character to the left of the cursor and scrolls
    the rest of the line left to fill the empty space.

<CTRL><right arrow>
    Moves cursor right one character, stopping at the
    end of the line. Upon encountering the right
    margin of the window, the editor keeps the cursor
    within the display by scrolling the line contents
    to the left one character.

<CTRL><left arrow>
    Moves cursor left one character at a time,
    stopping at the beginning of the line. When at
    the left margin of the window but not yet at the
    left end of the line, the editor keeps the cursor
    within the display by scrolling the line contents
    right one character.

3.3 Commands Unique to ACTION! Editor

<CTRL><SHIFT>D
    Deletes the current window from the screen. The
    window contents are cleared from memory and the
    window itself disappears from the screen.

<CTRL><SHIFT>F
    Finds a specified group of alphanumeric characters
    in text. If the character string is found, the
    cursor and window are moved to display it.

<CTRL><SHIFT>G
    Finds a user-specified tag anywhere in file (from
    any starting location). If found, the surrounding
    text is displayed and the cursor is positioned at
    the tag.

<CTRL><SHIFT>H
    Moves cursor to the beginning of the file (home).

<CTRL><SHIFT>I
    Alternates between the character Replace and the
    character Insert modes (the editor starts out in
    replace mode). The mode being switched to is
    shown in the message area. This command affects
    "<BACK S>" and "<RETURN>" handling.

<CTRL><SHIFT>M
    Goes to the ACTION! Monitor (Part III).

<CTRL><SHIFT>P
    After one or more lines are loaded into the copy
    buffer using <SHIFT><DELETE>, the cursor can be
    moved anyplace in the text. Pressing
    <CTRL><SHIFT>P causes the lines in the copy buffer
    to be pasted at the current cursor location.
    Succeeding text (with tags) is moved down.

<CTRL><SHIFT>R
    Reads a file from a peripheral storage device.
    The file name given must be compatible with the
    DOS you are using. If no device is specified in
    the file name, Dl: is assumed.

<CTRL><SHIFT>S
    String Substitution. This commands allows you to
    substitute a new string of up to 32 characters for
    an old one. Can also be used successively to
    substitute multiple occurances of the old string.

<CTRL><SHIFT>T
    Sets a tag. The position of the cursor in the
    text is marked invisibly by a one-character alpha-
    numeric tag assigned to that location.

<CTRL><SHIFT>U
    Undo text changes. This command restores a
    changed line to its unmodified state. Tags for
    that line are not restored. This command works
    only on a line not deleted by <SHIFT><DELETE> and
    while the cursor has not left that line.

<CTRL><SHIFT>W
    Writes a file to a peripheral storage device. The
    file name must be compatible with the DOS you are
    using.

<CTRL><SHIFT>]
    Moves the window right 1 column (useful for
    editing files with lots of indentation).

<CTRL><SHIFT>[
    Moves window to the left 1 column.

<CTRL><SHIFT><up arrow>
    Moves the current window up a complete window.
    For continuity between the old and new windows,
    the top line from the last window is the new
    window's bottom line.

<CTRL><SHIFT><down arrow>
    Moves the current window down 1 window. The new
    window's top line is pulled from the previous
    window's bottom line.

<CTRL><SHIFT>1

Moves from the second window to the first window. The cursor goes to the previous cursor position, if any.

<CTRL><SHIFT>2

Moves from the first window to the second window. If the second window has not been created previously in the current editing session, then the second window is created on the screen. The editor goes to the previous cursor position, if any.

<CTRL><SHIFT>>

Moves the cursor to the end of the line and displays that end of the line. If the line is longer than 38 characters, then the cursor moves to the end of the line and the line is displayed so that only the rightmost 38 characters show.

<CTRL><SHIFT><

Moves cursor to beginning of line and displays the beginning of the line. If the line is longer than 38 characters, then the cursor moves to the beginning of the line and the line is displayed so that only the leftmost 38 characters show.

<CTRL><SHIFT><BACK S>

At the beginning of a line, this command deletes the otherwise invisible and inaccessible <RETURN> (EOL). The lower line is appended to the end of the preceding line. The succeeding lines are moved up one line, as needed. At all other times, this command acts the same as <BACK S>.

<CTRL><SHIFT><RETURN>

Insert a <RETURN> into the text. The line containing the cursor is broken at the cursor. The portion of the line to the left of the cursor remains on the current line. The remainder of he line is inserted in a new, left-justified line immediately below the left-hand portion or the old line. The window is redrawn, as needed.

Chapter 4: Technical Considerations

4.1 Files from Other Text Editors

The editor can't handle files which don't contain
<RETURN> characters (EOL's) or have lines longer than
240 characters. Line lengths should be less than or
equal to the line width of your printer for the sake of
convenience.

4.2 Key Recognition

During command line entry (in the message area), only
the <ESC>, <BACK S>, and <CLEAR> command keys are
recognized. All text characters are allowed.

During regular text entry, all text characters and
commands are allowed.

4.3 "Out of Memory" Error

This condition can result from an editing session in
which you made quite a few insertions and/or
substitutions, or from typing in a file which is too
big (this will occur very rarely).

When you get this error, immediately write the text
file out to a storage device, and then restart ACTION!
(using the 'BOOT' command in the Monitor). You can
then go back to the Editor and read your text file back
in, and continue working on it.

Part III: The ACTION! Monitor

Part III: The ACTION! Monitor

Chapter 1: Introduction

Part III describes the ACTION! monitor - control center
of the ACTION! system.   It connects to all of the
functions in ACTION!.

```
                    +----------------+
+-----------+       |                |        +------------+
|           |       |    ACTION!     |        |            |
| compiled  |-------|    Monitor     |- - - - |    DOS     |
| program   |       |    Part  III   |        | Appendix D |
|           |       |                |        |            |
+-----------+       +----------------+        +------------+
                   /         |        \
                  /          |         \
                 /           |          \
                /            |           \
     +-----------+    +-----------+    +-----------+
     |           |    |           |    |           |
     | ACTION!   |    | ACTION!   |    | ACTION!   |
     | Editor    |    | Compiler  |    | Options   |
     | Part II   |    | Part V    |    | Menu      |
     |           |    |           |    | Part III  |
     +-----------+    +-----------+    +-----------+
```
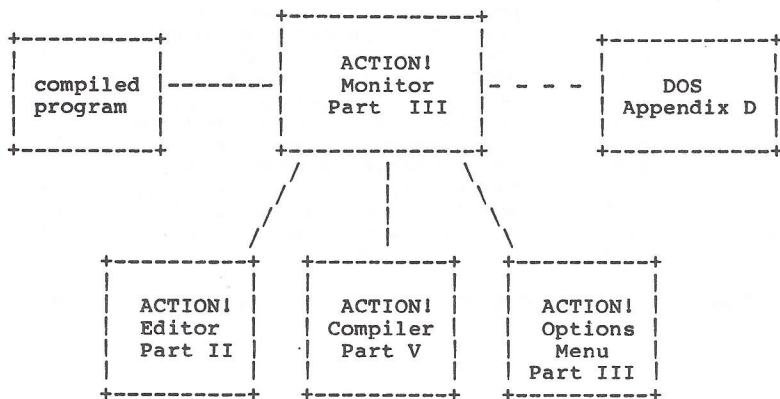
The monitor is characterized by an inverse video line
across the top of the screen, containing the prompt '>'
and the cursor at the left margin.

1.1 Vocabulary

```
              term                  where defined
              ----                  -------------
       <address>                      Part IV
       <compiler constants>           Part IV
       <filespec>                     below
       <identifier>                   Part IV
       <statement>                    Part IV
       <value>                        Part IV
```

When the term '<filespec>' is used in this part, it
refers to a standard Atari file specifier consisting of
a device (P:, C:, D1:, D2:, etc.) and a file name in
the case of disk drives.

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1.2 ACTION! Monitor Concepts and Features

The ACTION! monitor contains two chief features - the command line and the message area. Both are described below.

These areas are unique to the ACTION! monitor. However, the ACTION! compiler uses a similar screen format (see part IV on the ACTION! compiler).

You communicate with the ACTION! monitor through the command line. The command line is the inverted video line at the top of the screen. It contains both the prompt '>' and the cursor at the beginning of the line.

Commands are recognized by the first character entered after the prompt '>'. Thus, 'E', 'Edit', and 'Ejunk' all tell the ACTION! monitor to call the ACTION! editor. The various ACTION! monitor commands are summarized in chapter 2.

Below the command line is the message area. The message area is the large, outlined block in the middle of the screen. It is a multi-purpose area. When a program is running, it is used to display program results. It can also be used to trace program execution (see the óptions menu choice 'trace?' in chapter 2). When either the operating system or the ACTION! compiler finds an error, the message area contains the error number and the program text around the line where the error was found.

In its role as the command center of ACTION, you can move from the ACTION! monitor to any of several different ACTION! functions. To get an idea of the relationship between the various ACTION! parts, see the diagram on the preceding page. You can execute a compiled ACTION! program (see the ACTION! monitor's RUN command in Chapter 2). You can also call the ACTION! Editor (described in Part II) or call the ACTION! Compiler (described in Part V). If you are using disk drives, you can even call the DOS (see the ACTION! monitor DOS command, mentioned in Chapter 2).

Chapter 2: ACTION! Monitor Commands

2.1 BOOT - Restarting ACTION!

Sometimes you need to restart ACTION! from the ACTION!
monitor. This might occur after a fatal error or upon
return from DOS. You can restart ACTION! by entering
'BOOT', then pressing <RETURN>.

Examples: BOOT   <RETURN>
               B   <RETURN>

WARNING: text in the ACTION! Editor will be lost.
Compiled programs and their program variables will also
be lost.

2.2 COMPILE - Compiling Programs

In ACTION!, a program must be processed by the ACTION!
compiler before it can be run from the monitor. You
can call the ACTION! compiler from the monitor, using:

FORMAT: COMPILE "<filespec>"

The "<filespec>" is an option which allows you to
compile programs which are stored on a peripheral
device (disk, cassette, etc.). If no "<filespec>" is
specified, then the contents of the Editor buffer is
compiled. If you are using two windows, the file in
the window which contained the cursor when you left the
Editor is compiled.

If the Compiler finds a syntax error while compiling
the program, the error number and the line on which the
error occurred are display in the Monitor's message
area. The Compiler then returns control back to the
Monitor.

Examples:
        COMPILE   <RETURN>   (compile the program in the
        C   <RETURN>   current Editor window.)

        C "C:"   <RETURN>   (compile from cassette)

        C "D1:PRIME.ACT"   <RETURN>   (compile PRIME.ACT
        COMPILE "PRIME.ACT" <RETURN> from disk drive #1)

Notice that the file name specified in the last example
does not have a device given. If no device is given,
the device D1: is assumed.
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2.3 DOS - Transfer to DOS

You can transfer to OS/A+, DOS XL, or Atari DOS by
entering 'DOS', then pressing <RETURN>.

Examples: DOS   <RETURN>
                D   <RETURN>

NOTE: since Atari DOS and some of its utilities use the
same memory that ACTION! uses, you should always take
the precaution to save all files before going to Atari
DOS.

2.4 EDIT - Transfer to the ACTION! Editor

You can transfer to the ACTION! editor by entering
'EDITOR', then pressing <RETURN>.

Examples: EDITOR   <RETURN>
                E   <RETURN>

NOTE: if you were just compiling a program from the
editor and the compile failed due to a syntax error,
you will find that the ACTION! editor cursor is on the
line following the error.

2.5 OPTIONS - The Options Menu

The options menu allows you to alter certain
operational parameters of the ACTION! Monitor,
Compiler, and Editor. Enter the options menu by
entering OPTIONS, then pressing <RETURN>.

Examples: OPTIONS   <RETURN>
                O   <RETURN>

Each option is displayed in the command line. If you
want to change that option, type in the the value you
want, and press <RETURN>. If you don't want to change
that option, simply press <RETURN>. If you want to
exit the options menu all together, press <ESC>.

NOTE: a summary of the options available may be found
in appendix G.

Following is a description of each of the options
available. Each description contains the command line
prompt for that option, the initial state of that

option, and the components of the ACTION! system that
option affects (M = Monitor, C = Compiler, E = Editor).

Display?   Y   M,C,E

    The screen display can be turned off for greater
    speed during disk I/O and during ACTION! compiler
    processing. You can turn the screen display off
    (enter 'N') or you can leave it on (enter 'Y').

Bell?   Y   M,C,E

    The bell rings whenever errors are encountered in
    the ACTION! Monitor, Compiler, or Editor. It
    also rings whenever the ACTION! monitor is
    called. You can turn that bell off (enter 'N') or
    you can leave the bell on (enter 'Y').

Case sensitive?   N   C

    When this option is 'Y', distinction is made in
    variable names between upper and lower case
    letters (i.e., 'count' differs from 'Count' and
    'COUNT') and the language statements (e.g., FOR,
    WHILE, DO etc.) must be in upper case. However,
    for the ease of beginning ACTION! programmers,
    case sensitivity is turned off when you enter the
    ACTION! system.

Trace?   N   C

    With this option you can control the compiler's
    ability to trace program compilation. When this
    option is enabled ('Y'), the compiler will note in
    the Monitor's message area every routine call,
    together with the parameters passed to that
    routine. See chapter 4 for more information on
    the usage of this option.

List?   N   C

    The ACTION! compiler can be commanded to display
    the current line being compiled in the message
    area of the screen. Enter 'Y' to enable this
    listing or enter 'N' to disable this listing.

Window 1 size?   18   E

    The size of the ACTION! Editor's window 1 is set
    explicitly. Window 2 size is set implicitly by
    the relationship with window 1 -- the two windows
    have a combined size of 23 lines. When there are
    two windows, each can contain no less than 5 lines

and no more than 18 lines. Enter the number of
lines for window 1, then press <RETURN>. An entry
greater than 18 is converted to 18 and an entry
less than 5 is converted to 5.

Line size?   120   E

The line length is the number of characters in the
line, counting from the left margin (see next
option). The line length is used to help you
control the size of lines listed to the printer.
The bell sounds whenever the actual number of
characters in the line exceeds the entered line
length. You enter the number of characters of the
line length.

WARNING: you can set the line length to a value
which is out of the correct range. The options
menu does not check for this error. Lines longer
than 240 characters are arbitrarily shortened
by the ACTION! Editor.

Left margin?   2   M,E

The left margin is the starting point for the line
count mentioned earlier. This option is offered
so that you can get the full use of a screen which
displays the leftmost 2 characters (not all TV
screens can do this!). It is suggested that you
keep the left margin as close to the left edge of
the screen as you feel comfortable with. Normally
set at 2, you can set the left margin as low as 0
and as high as 39. Enter the appropriate left
margin location and then press <RETURN>.

WARNING: Do not enter a number greater than 39
when using an Atari system with the standard
display.

EOL character?   (blank)   E

The EOL (End Of Line) character is the character
displayed by the ACTION! editor at the end of a
line. Enter the character which you want to see
displayed as the visible EOL character, then press
<RETURN>. Changing from a space to a visible
character would generally only be useful for
removing trailing spaces from lines. However, you
may prefer a visible EOL for reasons of your own.
If you desire such, we suggest any of the Atari
graphics characters (e.g., <CTRL>T is a solid
circle).

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2.6 PROCEED - Restarting a Halted Program

Restart a halted program (continue from a stop caused
by pressing the <BREAK> key using the 'Break' Library
routine) by entering 'PROCEED', then pressing <RETURN>.
The program continues as if the interruption had not
occurred.

Examples:
      PROCEED   <RETURN>
      P   <RETURN>

2.7 RUN - Program Execution

You can run any program which has just been compiled
and is still in the program area. The command has the
following formats:

      RUN
      RUN "<filespec>"
      RUN <address>
      RUN <routine>

where <routine> is a valid PROC or FUNC identifier
(e.g., for 'PROC Prime()' you would use 'Prime' as the
routine identifier).

The first format is used to run a program you have
compiled from the Editor buffer.

The second allows you to run programs stored on
peripheral devices. If the program is still in the
ACTION! language, it is first compiled by the
Compiler, and then it is run. If it is in machine code
(i.e., you saved the compiled version of your program
using the 'WRITE' Monitor command), the program runs
immediately.

The third format allows you to run a program (or
routine) which begins at a given address. This is
useful when you are trying to debug a program which
calls a machine language routine you have written.

The fourth is used to run only one routine from a
program which you have compiled.

After program execution, control returns to the ACTION!
monitor. When some kind of significant error occurs
(e.g., an infinite loop), control does not return to
the ACTION! monitor. Such an error requires pressing
the <SYSTEM RESET> key in order to return to the

ACTION! monitor. Additional information on the behavior of running programs is in the next chapter.

Examples:
```
     RUN   <RETURN>    (run a program compiled
     R     <RETURN>     from the Editor buffer.)

     RUN "C:" <RETURN> (pull a program from cassette,
                         compile it, then run it)

     RUN "PRIME.ACT" <RETURN>   (pull PRIME.ACT from
     R "D1:PRIME.ACT" <RETURN>   disk #1, compile it,
                                 then run it)

     R $400 <RETURN>    (run a program at address $400)
     RUN 1024 <RETURN>  (run a program at address 1024)

     R Prime   <RETURN>      (run the just-compiled
                             procedure 'Prime()')
     RUN PrintE() <RETURN> (run the library function
                            to print a string to the
                            screen)
```

2.8 SET - Setting a memory value

The SET command in the Monitor works exactly as in the Language itself, so we will refer you there for a description of its usage. See part IV, section 7.3.

2.9 WRITE - Saving Compiled Programs

You can write a compiled program (called a binary file) to disk for later execution directly from DOS by entering 'WRITE', then, in quotes, a valid file specification. The format is:

        WRITE "<filespec>"   <RETURN>

The binary file in memory is saved to the specified file on the disk. The file is created, if necessary. If there isn't sufficient room on the disk, or the disk is write-protected, you are warned with an error message and can try again.

Examples:
```
     WRITE "PRIME.BIN" <RETURN>    (save a compiled
     W "D1:PRIME.BIN"  <RETURN>    version of the
                                   PRIME program to
                                   disk 1)

     W "C:"  (save the compiled program to cassette)
```

The OS or DOS command to execute a machine language
program can be used to execute a program saved to by
the 'W' command. See the references mentioned in
Appendix D.

2.10 XECUTE - Immediate Commands

You can execute any ACTION! language command or any
ACTION! compiler directive (except MODULE and SET) from the
ACTION! monitor. Preface any such command with the
command XECUTE, then the statement(s). Press <RETURN>.

Examples:
        XECUTE PrintE("Hello World") <RETURN>
        X trace = 255   <RETURN>

NOTE: using this command is very similar to the BASIC
direct mode.

2.11 ? - Display a Memory Location

You can display the value either of a variable or of a
specified memory location. Enter '?'. Then enter a
compiler constant. Press <RETURN>. The format is:

        ? <compiler constant>   <RETURN>

The ACTION! monitor shows you the actual memory
location (expressed in both decimal and hexadecimal
formats), followed by the printable ATASCII value of
that location, its four-digit hexadecimal value, the
decimal value of the BYTE, and the decimal value of the
CARD starting at the specified location. If the
identifier is not in the ACTION! compiler's symbol
table, then a "variable not declared error" occurs.

Example:

```
+------------------------------------------------+
|  >? $FFFE                                       |
+------------------------------------------------+
|   65535,$FFFE = s $E6F3  243  59123            |
|                                                |
|                                                |
|                                                |
|                                                |
|                                                |
|                                                |
|                                                |
|                                                |
+------------------------------------------------+
```

NOTE: the results might not be what you expect memory
has been altered since the compile - see SYMBOL TABLE
in Part V.

2.12 * - Memory Dump

Starting from a specified memory address, you can
display the memory contents of sequential locations in
a format identical to that described just above.
Simply enter '*' and the <address>. The format is:

          * <address>   <RETURN>

The monitor returns a list of the memory contents in
the variety of formats (mentioned above) at the rate of
one line per memory location. You can stop the listing
by pressing <space bar>. You can temporarily halt the
listing by entering <CTRL> 1. Press <CTRL> 1 a second
time to continue the listing.

Example:
```
+------------------------------------------+
|  >* $600                                 |
+------------------------------------------+
|   1536,$0600 = * $0000 0 0               |
|   1537,$0601 = * $0000 0 0               |
|   1538,$0602 = * $0000 0 0               |
|   1539,$0603 = * $0000 0 0               |
|   1540,$0604 = * $0000 0 0               |
|   1541,$0605 = * $0000 0 0               |
|   1542,$0606 = * $0000 0 0               |
|   1543,$0607 = * $0000 0 0               |
|   1544,$0608 = * $0000 0 0               |
|   1545,$0609 = * $0000 0 0               |
|   1546,$060A = * $0000 0 0               |
|   1547,$060B = * $0000 0 0               |
+------------------------------------------+
```

Chapter 3: Program Debugging Facilities

You have probably written programs which do not work
the way that you expected, not because of syntax
errors, but simply because something you're doing (or
think you're doing) isn't executing properly. With the
ACTION! Monitor and its options menu you can debug
your program step by step to determine where the error
is occuring.

The TRACE Option

      One of the options available in the options menu
      is 'Trace?'. If this option is enabled ('Y'), you
      can follow your program's execution. When the
      trace is on, every time a routine is called its
      name and parameters are displayed on the screen.
      You might be able to discover what is going wrong
      simply by looking at the order of the routine
      calls and/or the parameters being passed. If this
      is so, fantastic! If not, you probably need to do
      some major debugging.

The first thing you need to do before doing any major
debugging is to stop your program sometime during its
execution.   There   are .two ways to do this in ACTION!:
the <BREAK> key and the Library routine 'Break'.

The <BREAK KEY>

      Although the <BREAK> key is disabled during use of
      the ACTION! Editor, it is usable during program
      execution with certain restrictions. The <BREAK>
      key will stop program execution only if you are:

      1) doing some sort of I/O
      2) calling a routine with more than 3 parameters

      These might seem strange circumstances, but there
      is a good reason for them.   The ACTION! system
      itself does not check to see if the <BREAK> key
      has been pressed during program execution, but the
      system does make calls to CIO in the above two
      circumstances, and CIO checks to see if the
      <BREAK> key has been pressed.

Library PROC Break()

      If you want program execution to stop at any given
      place, simply make a call to this Library routine
      at that point. This routine acts exactly like the
      <BREAK> key, except that it works under all

circumstances. Using this method to stop a
program is more reliable than pressing <BREAK>
because you know exactly where you are in the
program when the program stop occurs.

NOTE: you may use this routine more than once in
one program if you want to break execution at more
than one place.

Now that you have stopped the program, you can use the
Monitor commands '*' and '?' to look at the value of
the variables you're using. If this method of
debugging is used with the 'Trace' option on, you can
even find out where you are in your program (if you are
using the Library 'Break', you already know where you
are) and so look at the variables local to the
procedure you're in as well as the global ones.

If this method doesn't work, we can only suggest that
you insert diagnostic 'Print' statements into your
program (e.g., PrintE("In loop FOR x=1 to 100")
PrintBE(x) might be used to debug a FOR loop which has
run amuck).

Part IV: The ACTION! Language

PART IV: The ACTION! Language

Chapter 1:   Introduction

The ACTION! language is the heart of the ACTION!
system.   It incorporates the good points of both C and
PASCAL and, at the same time, is the fastest high
level language available for ATARI home computers. If
you have a background in BASIC   or   some   other
unstructured language, you will find ACTION! a welcome
change because its structure is similar to the way we
structure ideas in our own minds.   You can actually
look at an ACTION! program someone else has written
and understand what is going on, without having to wade
through a thousand GOTOs and undeclared variables.

Program   structure   is simple   in   ACTION!,   because
programs are built component by   component.   The
components are groups of related statements which
accomplish some task. When you have written components
for all the tasks required in your program,   it   is   a
simple matter to execute them.   It's very similar to a
list of chores, such as

            1.)   Make your bed
            2.)   Clean your room
            3.)   Dust the living room furniture
            4.)   Wash the Dog

except that the computer will do the tasks in the order
in which you present them, not in whatever order it
likes best.

Having separate components also makes it very easy   for
you to do a single task over and over, or do the same
task in ten different situations and places.

The   only   requirement this structured approach imposes
is that a program must consist of proper components (in
ACTION! they are called procedures and functions)   for
it to be valid.   A program usually contains many
components, but at least one is required. This is   not
a restrictive requirement at all, as you will soon find
out.   In   fact,   it   makes   your   program   more
comprehensible to yourself and others.

NOTE: when   compiling and running a program with many
routines, the last routine is considered to be the main
one, so you should use it to control you program.

Chapter 2: ACTION! Vocabulary

In our discussion of ACTION! we will use some
terminology that we should explain. We'll use as
little jargon as possible, but some is required to
differentiate between parallel but different concepts
later on. What terms we don't present here will be
explained when they're first used. Before going into
the special notations used in this part, we'll give you
a list of the keywords in ACTION!. A "keyword" is any
word or symbol the ACTION! compiler recognizes as
something special, whether it be an operator, a data
type name, a statement, or a compiler directive:

AND	FI	OR	UNTIL	=	(
ARRAY	FOR	POINTER	WHILE	<>	)
BYTE	FUNC	PROC	XOR	#	.
CARD	IF	RETURN	+	>	[
CHAR	INCLUDE	RSH	-	>=	]
DEFINE	INT	SET	*	<	"
DO	LSH	STEP	/	<=	'
ELSE	MOD	THEN	&	$	;
ELSEIF	MODULE	TO	%	^	
EXIT	OD	TYPE	!	@	

WARNING: You may not use the above keywords in any
context other than the one defined in the ACTION!
language; specifically, you may not use these words as
identifiers.

2.1 Special Notations

When discussing the language, we use some terms which
might be unfamiliar to you, so their meanings are
presented here. The list is in alphabetical order,
with the symbols at the end.

Address   An address is a location in memory. When
              you tell the computer to put something into
              memory, you must give it an address, just
              like you give the post office the address
              of the destination of a letter on the
              letter's front. In the computer there are
              only house numbers, no streets, no cities,
              no states, and no zip codes. So an address
              to the computer is simply a number.

Alphabetic   Any letter of the alphabet, in either upper
              (ABC) or lower (abc) case. "Alphanumeric"
              includes the digits "0" through "9" as well.

Identifier   Throughout the manual we will refer to the
              names you give to variables, procedures,
              etc.   as   identifiers. We do this because
              names in   ACTION!   must   follow   some
              guidelines:

              1.   They must start with an alphabetic
                    character
              2.   The rest of the characters must be
                    alphanumeric, or the underline (_)
                    character.
              3.   They may not be keywords.

              These rules must be obeyed when you wish to
              create an identifier, otherwise you will
              get a syntax error.

MSB, LSB   MSB stands for "Most Significant Byte", and
              LSB stands for "Least Significant Byte".
              In the decimal system we have significant
              digits, not bytes. For example, the most
              significant digit of '54' is '5', and the
              least significant is '4'. If you are un-
              familiar with the byte storage system,
              don't worry. You can program very well in
              ACTION! without knowing anything about the
              internal workings of the computer.

              Note that two-byte numbers stored and used
              by ACTION! are generally in LSB, MSB order,
              as is conventional on 6502-based machines.

$ The dollar sign, when used in front of a
              number, tells the computer that the number
              is hexadecimal (the base 16 number system
              useful when working directly with   the
              computer), not the customary decimal.

                  Examples:
                        $24FC $0D
                        $88 $F000

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;	The semicolon is the comment symbol, and everything on a line after it is ignored by the compiler.

Examples:
```
;This is a comment
This is not and will cause a
compiler error
; This comment has a ; semi-
;colon in it
var=3       ;comments can come
            ;after executable
            ;statements
;this is a 3 line comment
;
;with a blank line in it
```

< and >	Whatever is between these two symbols is used to define some part of a format. It is never a keyword, and usually is a term describing what goes in its place in the construction (e.g., <identifier> means a valid identifier should be used).
{ and }	Whatever is between these is optional in the format construction ({<identifier>} means that a valid identifier may be used here, but is not required).
|: and :|	As in music, these symbols denote repetition. Anything between them is repeatable from zero times on up (e.g., |:<identifier>:| means that you could have a list of zero or more identifiers here).
|	This symbol shows an 'or' situation (e.g., <identifier> | <address> means you could use either an identifier or an address, but not both.

Chapter 3: Fundamental Data Types

Before discussing the Fudamental Data Types, something
must be said about variables and constants, since they
are the basic data objects the computer manipulates.

3.1 Variables

Legal variable names must be valid identifiers. Other
than this there is no restriction on variable names.
Because a working knowledge of functions and procedures
is required before discussing the scope of a variable,
the topic is presented later in section 6.3.

3.2 Constants

There are three types of constants in ACTION!: numeric
constants, string constants, and compiler constants.

Numeric constants may be entered in three different
formats:

        1)   Hexadecimal
        2)   Decimal
        3)   Character

Hexadecimal constants are represented by a dollar sign
($) in front of the number.

Examples:
        $4A00
        $0D
        $300

Decimal constants require no special character to
define them as decimal.

Examples:
        65500
        2
        324
        46

NOTE: Both hexadecimal and decimal numeric constants
may have a negative sign in front of them, thus:
                        -$8C
                        -4360

Character constants are represented by a single quote
(') preceeding the character. Characters are numeric
constants because they are internally represented as
one byte numbers, as per the ATASCII character code
set.

Examples:
```
        'A
        '@
        '"
        'v
```

String constants consist of a string of zero or more
characters enclosed by double quotes ("). When stored
in memory, they are preceeded by their length. The
double quotes are not considered as part of the string;
if you want a " in your string, place two double quotes
together (see examples).

Examples:
```
        "This is a string constant"
        "a "" double quote in a string"
        "58395"
        "q"             (a single character string constant)
```

Compiler constants are different from the above types
of constants, in that they are used at compile time to
set certain attributes of variables, procedures,
functions, and code blocks, and are not evaluated at
run-time. The following formats are valid:

        1) A Numeric Constant
        2) A Predefined Identifier
        3) A Pointer Reference (see section 8.1.2)
        4) The Sum of Any Two of the Above

We have already talked about the first format, but the
other three require some explanation. When you use a
predefined indentifier (i.e., a variable, procedure or
function name) in a compiler constant, the value used
is the address of that identifier. The third format
allows pointer references as compiler constants. The
last one permits you do simple addition of a
combination of any two of the other three types. Here
are some examples which show the valid formats in use:

```
        cat     ;uses the address of the variable 'cat'
        $8D00   ;a hex constant
        dog^    ;a pointer reference as a constant
        5+ptr^  ;5 plus the contents of the pointer 'ptr'
        $80+p   ;evaluates to $80 plus the address of 'p'
```

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3.3 Fundamental Data Types

Data types allow humans to make sense out of the stream
of bits the computer understands and manipulates. They
allow us to use concepts we understand, so we need not
know how the computer does what it does.   ACTION!
supports three fundamental types and some advanced
extensions of these (see chapter 8 for the extended
types).   The basic ones are BYTE, CARD, and INT, and
each is detailed below. All of the fundamental types
are numeric, and so allow you to use numeric format
when entering data.

3.3.1 BYTE

The type BYTE is used for positive integers less than
256.   It is internally represented as a one-byte,
unsigned number -- its values range between Ø and 255.
At first glance this might seem a useless type, but it
has two worthwhile applications.   When used as a
counter in loops (WHILE, UNTIL, FOR) program speed will
increase because it's easier for the computer to
manipulate one byte than many.

Also, since characters are represented inside the
computer as one-byte numbers, BYTE is also useful as a
character type. In fact, the ACTION! compiler allows
you to use the keywords BYTE and CHAR interchangably,
so those of you with PASCAL or C experience can use
CHAR when dealing with characters and feel more at
home.

3.3.2 CARDinal

The CARD type is very similar to the BYTE type, except
that it handles much larger numbers. This is because
it is internally represented as a two-byte unsigned
number. Hence its values range from Ø to 65,535.

TECHNICAL NOTE: a CARD is stored in the LSB, MSB form
which is standard on 65Ø2-based machines.

3.3.3 INTeger

This type is like BYTE and CARD in that it is integer only, and can be entered in numeric format, but that is where the similarity ends. INT allows both positive and negative numbers ranging from -32768 to 32767. It is internally represented as a two byte signed number.

TECHNICAL NOTE: INTs are stored LSB, MSB like CARDs.

3.4 Declarations

Declarations are used to let the computer know that you wish to define something. For example, if you want the variable 'cost' to be of the type CARD, somehow you have to tell this to the computer. Otherwise the computer won't know what to do when it sees 'cost'.

Every identifier you use must be declared before it is used, whether it's a variable, procedure, or function name. Variable declarations will be explained here, followed by a note about numeric constant declarations; procedure and function declarations are explained in chapter 6.

3.4.1 Variable Declaration

The procedure for declaring a variable is the same no matter what fundamental type you want it to be. The basic format is:

 <type> <ident>{=<init info>} |:,<ident>{=<init info}:|

where

<type>	is the fundamental type of the variable(s) being declared
<ident>	is an identifier naming the variable
<init info>	allows you to initialize the value of the variable, or define the memory location of that variable

'<init info>' has the form:

        <addr> | [<value>]

where
        <addr>   is the address of the variable,
                            and must be a compiler constant
        <value>   is the initial value of that
                            variable, and must be a numeric
                            constant

NOTE: an explanation of <, >, {, }, |:, :|, and | can
be found in the vocabulary (chapter 2).

Notice that you can optionally have more than one
variable declared by one <type>. You can also
optionally tell the compiler where you want each
variable to reside in memory or initialize the variable
to a value. The following examples should help clarify
this format:

        BYTE top,hat   ;declare 'top' and 'hat' as BYTE
                            ;variables

        INT num=[0]   ;declare 'num' as an INT varia-
                            ;ble and initialize it to 0

        BYTE x=$8000,   ;declare 'x' as BYTE, placing it
                            ;at memory location $8000
            y= [0]   ;declare and initialize 'y'

        CARD ctr=[$83D4],   ;declares and initializes
             bignum=[0],   ;three variables as CARD
             cat=[30000]   ;type

In the last two examples you may note that the
variables need not be on the same line. The ACTION!
compiler will keep reading in variables of the type
given as long as there are commas separating them, so
remember not to put a comma after the last variable in
a list (strange things will happen if you do).

Variable declarations must come immediately after a
MODULE statement (see section 7.4) or at the beginning
of a procedure or function (see sections 6.1.1 and
6.2.1). If you use them anywhere else, you will get an
error.

3.4.2 Numeric Constants

Numeric constants are not explicitly declared. Their
usage declares their type. A numeric constant is
considered to be of type BYTE if it is less than 256,
otherwise it is considered to be of type CARD. For all
practical purposes, negative constants (e.g. -7) are
treated as type INT:

Constant	Type
543	CARD
$ØD	BYTE
$F42	CARD
'W	BYTE

Chapter 4: Expressions

Expressions are constructions which obtain values from
variables, constants, and conditions using a specific
set of Operators. For example, '4+3' is an expression
that equals '7' as long as we take the '+' operator to
mean addition. If the operator were '*' instead,
multiplication would result, and the expression would
equal '12' (4*3=12). ACTION! has two types of
expressions, arithmetic and relational. The example
given above is an arithmetic expression. Relational
expressions are those which involve a 'true' or 'false'
answer. '5 >= 7' is false if we take '>=' to mean "is
greater than or equal to". This type of expression is
used to evaluate conditional statements (see section
5.2.1). A conditional statement in every day life
might be, "If it is five o'clock or later, then it's
time to go home." An ACTION! relational expression
for this might be:

$$hour >= 5$$

You yourself make this check (and many others)
automatically when you look at a clock, but the
computer needs to be told exactly what to check for.

Before going into the expressions themselves, we need
to define the operators that apply to each type of
expression. After that we'll discuss each expression,
and then go into some special extensions of relational
expressions.

4.1 Operators

ACTION! supports three kinds of operators:

    1)   Arithmetic operators
    2)   Bit-wise operators
    3)   Relational operators

As suggested by the names of the first and last, they
specifically pertain to an expression type. The second
class of operators performs arithmetic and addressing
operations at bit level.

4.1.1 Arithmetic Operators

The arithmetic operators are those we commonly use in math, but some are modified so that they can be typed in from a computer keyboard. Here is a list of those ACTION! supports, each followed by its meaning:

```
-      unary minus (the negative sign) Ex:  -5
*      multiplication Ex:  4*3
/      integer division  Ex:  13/5 (this equals 2,
                   since the remainder is dropped)
MOD    remainder of integer division  Ex: 13 MOD 5
                   (this equals 3, since 13/5 =2
                   with a remainder of 3)
+      addition Ex:  4+3
-      subtraction  Ex:  4-3
```

Notice that '=' is not an arithmetic operator. It is used only in relational expressions, certain declarations, and assignment statements.

4.1.2 Bit-wise Operators

Bit-wise operators manipulate numbers in their binary form. This means that you can do operations similar to those the computer does (since it always works with binary numbers). The following list summarizes the operators:

```
&      bit-wise 'and'
%      bit-wise 'or'
!      bit-wise 'exclusive or'
XOR    same as "!"
LSH    left shift
RSH    right shift
@      address of
```

The first three compare numbers bit by bit and return a result dependent on the operator, as seen below.

		Bit-wise And	
& compares the two bits,	Bit A	Bit B	Result
returning a value	1	1	1
based on this table:	0	1	0
	0	0	0
	1	0	0

```
Example: 5 & 39 -- 00000101  (equals 5 decimal)
                   00100111  (equals 39 decimal)
               & ----------
                   00000101  (result of & is 5)
```

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```
                                                    Bit-wise Or
% returns a value depen-        Bit A    Bit B    Result
    dent on this table:           1        1        1
                                  0        1        1
                                  0        0        0
                                  1        0        1

    Example: 5 % 39 -- 00000101  (5)
                       00100111  (39)
                    % -----------
                       00100111  (result of % is 39)


                                                    Bit-wise XOR
! returns a value depen-        Bit A    Bit B    Result
    dent on this table:           1        1        0
                                  1        0        1
                                  0        0        0
                                  0        1        1

    Example: 5 ! 39 -- 00000101  (5)
                       00100111  (39)
                    ! -----------
                       00100010  (result of ! is 34)
```

Both LSH and RSH shift bits. If they operate on
two-byte types (CARD and INT) the shift occurs through
both bytes. In the case of INT, the sign of the number
is not preserved when using RSH or LSH, and may change.
Their form is:

```
        <operand> <operator> <number of shifts>
```

where

<operand>	is a numeric constant or variable
<operator>	is either LSH or RSH
<number of shifts>	is a numeric constant or variable used to determine the number of single bit shifts to do

Some examples to illustrate both LSH and RSH follow:

```
(5)                00000101   (39)                00100111
(5 LSH 1 = 10)     00001010   (39 LSH 1 = 78)     01001110
(5 RSH 1 = 2)      00000010   (39 RSH 1 = 19)     00010011

operation    MSB        LSB
   ---     01010110  11001010   ($56CA)
LSH 1      10101101  10010100   ($56CA LSH 1 =$AD94)
RSH 1      00101011  01100101   ($56CA RSH 1 =$2B65)
LSH 2      01011011  00101000   ($56CA LSH 2 =$5B28)
RSH 2      00010101  10110010   ($56CA RSH 2 =$15B2)
```

Notice that a LSH by one is the same as multiplying by
two, and a RSH by one is like division by two (for
positive numbers). In fact, this method of
multiplication and division is faster than using '*2'
and '/2' because it is closer to what the computer
understands, so the computer doesn't need to translate
the expression into its own binary operation format.

The '@' operator gives the address of the variable to
its right. It cannot be used with numerical constants.
'@ctr' will return the address in memory of the
variable 'ctr'. The '@' operator is very useful when
dealing with pointers.

4.1.3 Relational Operators

Relational operators are allowed only in relational
expressions, and relational expressions are allowed
only in IF, WHILE, and UNTIL statements. Relational
operators may not appear anywhere except in these
statements. As outlined in the overview of this
section, relational operators test conditions of
equality. A table of the ACTION! relational operators
follows:

```
    =     tests for equality  Ex:  4=7 (this is obvi-
                        ously false)
    #     tests for inequality  Ex: 4#7 (true)
    <>    same as "#"
    >     tests for greater than  Ex:  9>2 (true)
    >=    tests for greater than or equal to  Ex: 5>=5
                        (this is true)
    <     tests for less than  Ex:  2<9 (true)
    <=    tests for less than or equal to  Ex: 5<=5 (this
                        is true)
    AND   logical 'and'; see section 4.4
    OR    logical 'or'; see section 4.4
```

Both '#' and '<>' mean the same thing to ACTION!, so
you may use the one you prefer. 'AND' and 'OR' are
special relational operators, and are discussed in
'Complex Relational Expressions', section 4.4.

TECHNICAL NOTE: the ACTION! Compiler does comparisons
by subtracting the two values in question and comparing
the difference to 0. This method works correctly with
one exception -- if you are comparing a large positive
INT value with a large negative INT value, the outcome
could be wrong (since INTs use the highest bit as a
sign bit).

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4.1.4 Operator Precedence

Operators require some kind of precedence, a defined
order of evaluation, or we wouldn't know how to evalu-
ate expressions like:

                    4+5*3

Is this equal to (4+5)*3 or 4+(5*3)? Without operator
precedence it's impossible to tell. ACTION!'s
precedence is very precise but can be circumvented by
using parentheses, since they have the highest
precedence. In the following table the operators are
listed in order of highest to lowest precedence.
Operators on the same line have equal precedence and
are evaluated from left to right in an expression (see
examples).

( )	parentheses
- @	unary minus, address
* / MOD LSH RSH	mult,div,rem, etc...
+ -	addition,subtraction
= # <> > >= < <=	relational operators
AND &	logical/bit-wise and
OR %	logical/bitwise or
XOR !	bitwise exclusive or

According to this table, our earlier example, 4+5*3,
would be evaluated as 4+(5*3) because the '*' is of
higher precedence than the '+'. What if (4+5)*3 were
intended? You'd have to include the parentheses, as
shown, to override the normal operator precedence.
Here are some examples to look over:

expression	result	evaluation order
4/2*3	6	/,*
5<7	true	<
43 MOD 7*2+19	21	MOD,*,+
-((4+2)/3)	-2	+,/,-

4.2 Arithmetic Expressions

An arithmetic expression consists of a group of
numerical constants, variables, and operators ordered
in such a way that there is a numerical result. The
order is as follows:

        <operand> <operator> <operand>

where '<operand>' is a numeric constant, numeric
variable, FUNCtion call (see section 6.2.3), or another
arithmetic expression. The first three possibilities
are straightforward enough, but the last one is a
problem. Here's an example to show you what we mean:

        starting expression: 3*(4+(22/7)*2)

order	expression	evaluation	simplified exp
start	3*(4+(22/7)*2)	----	-----
1	(22/7)	3	3*(4+3*2)
2	(22/7)*2	6	3*(4+6)
3	(4+(22/7)*2)	10	3*10
4	3*(4+(22/7)*2)	30	30

'order' is the order of the expression evaluation,
'expression' shows which expression is being evaluated,
'evaluation' shows the evaluation of that expression,
and 'simplified exp' shows the expression after the
evaluation has taken place.

Notice that expressions 2 through 4 contain another
expression as one of their operands, but that this
"expression as an operand" has already been evaluated,
leaving a number in its place, as seen in 'simplified
exp'.

Some examples follow (all lowercase words are variables
or constants):

expression	evaluation order
'A*(dog+7)/3	+,*,/
564	(none)
var & 7 MOD 3	MOD,&
ptr+@xyz	@,+

Arithmetic expressions in ACTION! may involve operands
of differing data types. The result of such mixing is
outlined in the table below. The type at the
intersection of any row and column is the type
resulting when the row's and column's types are mixed:

```
         | BYTE    INT     CARD
   ------+------+------+------
   BYTE | BYTE    INT     CARD
        +
   INT  | INT     INT     CARD
        +
   CARD | CARD    CARD    CARD
```

NOTE: using the unary minus (negative sign '-') results
in an implied INT type, and using the address operator,
'@', results in an implied CARD type.

TECHNICAL NOTE: using the '*' operand results in an INT
type, so multiplication of very large CARD values (>
32767) will not work properly.

4.3 Simple Relational Expressions

Relational expressions are used in conditional state-
ments to perform tests to see whether a statement
should be executed (more on conditional statements in
section 5.2.1). Note that they may be used ONLY in
conditional statements (IF, WHILE, UNTIL).

There may be only one relational operator in a simple
relational expression, so tests for multiple conditions
must be handled differently (They are covered in the
following section on complex relational expressions).
The form of a simple relational expression is:

        <arith exp><rel operator><arith exp>

where
        <arith exp>   is an arithmetic expression
        <rel operator>   is a relational operator

Here are some samples of valid relational expressions:

        @cat<=$22A7
        var<>'y
        5932#counter
        (5&7)*8 >= (3*(cat+dog))
        addr/$FF+(@ptr+offset) <> $F03D-ptr&offset
        (5+4)*9 > ctr-1

4.4 Complex Relational Expressions

Complex relational expressions allow you to cover a
wider range of tests by including multiple tests. If
you want to do something only on Sundays in July, how
do you get the computer to test whether it's Sunday and
then test whether it's July? ACTION! allows you to do
this kind of multiple testing with the AND and OR
operators (remember how they were glossed over in
section 4.1.3?). The compiler treats these as special
relational operators to test a condition using simple
relational expressions. The form is:

         <rel exp><sp op><rel exp>|:<sp op><rel exp>:|

where
         <rel exp>   is a simple relational expression
         <sp op>   is one of the special operators AND
                       or OR

NOTE: there are no exceptions to this form. If you try
something else, you will usually get the compiler error
'Bad Expression'.

The truth table below shows what each of these
operators will do in a given situation. 'exp 1' and
'exp 2' are the simple relational expressions on either
side of the special operator; 'true' and 'false' are
the possible results of a relational test.

```
              RELATIONALS |    RESULTS
            ---------------+---------------
            exp 1 | exp 2 |  AND  |  OR
            ------+-------+-------+------
            true  | true  | true  | true
                  +       +       +
            true  | false | false | true
                  +       +       +
            false | true  | false | true
                  +       +       +
            false | false | false | false
```

NOTE: you may use parentheses around one segment of a
complex relational expression to insure the order of
evaluation. If you don't do this, the expressions are
evaluated in left to right order. (see Examples)

WARNING: at the writing of this manual, the ACTION!
compiler sees the pairs AND -- &, and OR -- % as
synonyms, and they are evaluated in the same way
(bit-wise). If you follow the rules outlined above
when using them, you should have no problems. Also, if

you stick to using 'AND' and 'OR' only in the relational sense, and '&' and '%' only in the bit-wise sense, your programs will be compatible with possible upgrades of ACTION!.

Here are some samples of valid complex relational expressions:

```
cat<=5 AND dog<>13
(@ptr+7)*3 # $60FF AND @ptr <= $1FFF
x!$F0<>0 OR dog>=100
(8&cat)<10 OR @ptr<>$0D
cat<>0 AND (dog>400 OR dog<-400)
ptr=$D456 OR ptr=$E000 OR ptr =$600
```

Here's a confusing situation:

```
$F0 AND $0F
```

is false because the 'AND' is seen as a bit-wise operator being used in an arithmetic expression, whereas

```
$F0<>0 AND $0F<>0
```

is true because the 'AND' joins two simple relational expressions, and so is a special operator as used in complex relational expressions.

Chapter 5:   Statements

A computer program would be useless if it could not
actively operate on data. You would be allowed to
declare variables, constants, etc., but there would be
no way to manipulate them. Statements are the active
part of any computer language, and ACTION! is no
exception. Statements translate an action you want to
do into a form which the computer can understand and
execute properly. This is why statements are sometimes
referred to as executable commands.

There are two classes of statements in ACTION!: simple
statements and structured statements. Simple state-
ments contain no other statements within themselves,
whereas structured statements are collections of other
statements (either simple or structured) put together
following a certain order. Structured statements may
be broken down into two categories:

         1)   Conditional Statements
         2)   Looping Statements

Each category is discussed separately in the section on
structured statements.

5.1 Simple Statements

Simple statements are those which do one thing only.
They are the basic building blocks of a program, since
any action the computer performs is a simple statement
of one kind or other. There are two simple statements
in ACTION!:

         1)   Assignment Statement (including FUNCtion Calls)
         2)   PROCedure Calls

PROCedure and FUNCtion calls are discussed in chapter
6, and the assignment statement follows. There are two
keywords that are also simple statements,

         EXIT   section 5.2.3.2
         RETURN   sections 6.1.2 and 6.2.2

but the last two are used in specific constructs, and
so are discussed where appropriate to their usage.

5.1.1 Assignment Statement

The assignment statement is used to give a value to a variable. Its most common form is:

        <variable>=<arithmetic expression>

NOTE: <variable> may be a variable of a fundamental data type, or it can be an array, pointer, or record reference.

NOTE: the expression MUST be arithmetic! If you try to use a relational expression, you will get an error, because the ACTION! compiler does not assign a numerical value to the evaluation of a relational expression.

The assignment operator is '='. It tells the computer that you want to assign a new value to the given variable. Do not confuse it with the relational '='. Although they are the same character, the compiler reads them differently, each according to its context.

The following examples illustrate the assignment statement. You'll notice a variable declaration section preceding the examples themselves. It's there because some of the examples show what happens when you mix types (i.e. the variable and value being assigned to it are not of the same data type).

BYTE b1,b2,b3,b4
INT i1
CARD c1

b3='D   puts the ATASCII code number for
                         'D' into the byte reserved for
                         'b3'.

b4=$44   puts the hex number $44 into the
                         byte reserved for the BYTE vari-
                         able 'b4' ($44 is "D" in ATASCII
                         and so 'b3' and 'b4' now contain
                         the same thing).

b1=b4+16   adds 16 to the numerical value
                         of 'b4', and puts the result
                         into the byte reserved for 'b1'.

c1=23439-$07D8   puts the value 21431 ($53B7) in
                         the two bytes reserved for 'c1'.

```
il=cl*(-1)              puts the value -21431 ($AC49) in
                        the two bytes reserved for 'il'.

b2=il                   puts the value $49 (73) into the
                        byte reserved for 'b2'.    Notice
                        that  the computer takes the LSB
                        of 'il' to  put  into 'b2'  (the
                        MSB of il is $AC; LSB is $49).

b2=b2+1                 adds  1  to the current value of
                        'b2' and  stores  the  sum  back
                        into  'b2'.  'b2'  now  contains
                        $4A (74).
```

Notice that the last example's form is:

    <var>=<var><operator><operand>

Since programmers often use the above format, ACTION!
allows the following shorthand form to do the same
thing:

    <var>==<operator><operand>

The operator must be either arithmetic or bit-wise.
The operand must be an arithmetic expression.   The
following are some examples of this shorthand form:

```
b2==+1          is the same as      b2=b2+1
b2==-bl         is the same as      b2=b2-bl
b2==& $ØF       is the same as      b2=b2 & $ØF
b2==LSH (5+3)   is the same as      b2==b2 LSH (5+3)
```

This shorthand form can save you a lot of typing over
the long method and even generates better machine code
in some instances.

5.2 Structured Statements

If only simple statements were available, you'd be severely limited in the number of things you could do on a computer:

> The only way you could repeat a group of statements a number of times would be to type them out in the same order the right number of times. If you wanted to repeat a group of ten statements ten times, you would end up typing in 100 statements!

> You would not be able to execute a group of statements conditionally, that is, only execute them if some specified test is satisfied.

The purpose of structured statements is to solve these and other problems. Structured statements as a whole are divided into two separate categories: Conditional Statements and Looping Statements. We will discuss each of these categories separately.

5.2.1 Conditional Execution

Conditional execution allows you to test an expression and execute various statements depending on the outcome of the test. Since the expression controls conditional execution, it is called a conditional expression.

Three ACTION! statements allow conditional execution:

IF   WHILE   UNTIL

WHILE and UNTIL are looping statements and will be dealt with later, but we'll discuss IF immediately after the rules governing conditional expressions.

5.2.1.1 Conditional Expressions

Since a conditional expression is involved in a test, there are only two values it may have -- true or false. This does not mean a conditional expression is a new type of expression, however. In fact, a conditional expression is simply either a relational or arithmetic expression. Only the interpretation is different. The following table shows what the conditional interpretation is, depending on which type of expression it is:

Expression Type	Normal Result	Conditional Result
arithmetic	zero (0)	false
	non-zero	true
relational	false	false
	true	true

5.2.1.2 IF Statement

The IF statement in ACTION! is much like the 'if' conditional statement in english. For example:

        "If I have $9 or more, I'll buy the steak."

In ACTION! the same statement might be:

```
BYTE money,
     steak=[9],
     fish=[8],
     chicken=[6],
     hotdog=[2]

IF money>=9 THEN
   buy(steak,money)
FI
```

NOTE: buy(steak,money) is a procedure call and will be dealt with in section 6.1.3.

From the above example you can see that the basic form of the IF statement is:

```
IF <cond. exp.> THEN
   <statement(s)>
FI
```

'FI' is not part of "Fe fi fo fum...", but 'IF' spelled
backwards, and a keyword to the compiler showing the
end of an IF statement. Since IF can work on a list of
statements, we need 'FI' to terminate that list.
Without this keyword the compiler would not know how
many of the statements following the THEN went with the
IF statement.

The above is only the basic format. The IF statement
has two options, ELSE and ELSEIF. English also has
these options, so we'll use comparative examples:

> "If I have $9 or more I'll buy the steak,
> otherwise I'll buy the fish platter."

The ACTION! equivalent of this is:

```
IF money>=9 THEN
   buy(steak,money)
ELSE
   buy(fish,money)
FI
```

ELSEIF is somewhat different:

> "If I have $9 or more I'll buy the steak. If I
> have between $8 and $9 I'll buy the fried fish.
> If I have between $6 and $8 I'll buy the
> chicken. Otherwise I'll buy the hotdog."

would be:

```
IF money>=9 THEN
   buy(steak,money)
ELSEIF money>=8 THEN
   buy(fish,money)
ELSEIF money>=6 THEN
   buy(chicken,money)
ELSE
   buy(hotdog,money)
FI
```

in ACTION!. Notice that we don't have to check for
"money>=8 AND money<9", as in English. We can do this
because the computer goes through the list sequentially
from top to bottom. If any conditional case is true,
the statements it controls are executed, and then the
whole rest of the IF statement (including all following
ELSEIFs and ELSEs) is skipped. So, if the computer
does get to "money>=8", we already know that we have
less than $9, because the preceeding conditional tested
for "money>=9" and found that condition false.

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The ELSEIF option is very useful when you want to test a variable for a number of different conditions, each requiring a different action.

5.2.2 Null Statement

The null statement is used to do nothing. After showing you some statements that do something, and after stressing the necessity of statements that do something, why a statement that does nothing? There are actually a couple of good uses for a statement that does nothing: Timing Loops and ELSEIF cases.

Since we haven't yet discussed loops at all, we'll simply say that timing loops are used as a time delay (e.g., if you want to pause between printing lines to the the screen, you just use a timing loop to waste a few moments). You can find an example of a timing loop in section 5.2.4.1.

To illustrate the use of the null statement in ELSEIF cases, here's an example:

    Scenario: You are writing a program that allows stock brokers to find out information about certain stocks, using the commands you have made available. The commands you're implementing are: BUY, DOWN?, FIND, QUIT, SELL, and UP?, but you haven't implemented FIND yet. All you do is test the first letter of the entered command, so you have to test for B,D,F,Q,S, and U. But FIND isn't done, so what do you do when they type 'F'? Easy, you do nothing, hoping that someday (when FIND is ready) you'll do something. Here's how the program fragment might look:

```
IF chr='B THEN
   dobuy()
ELSEIF chr='D THEN
   dodown()
ELSEIF chr='F THEN
   ;**** here's the null statement
ELSEIF chr='Q THEN
   doquit()
ELSEIF chr='S THEN
   dosell()
ELSEIF chr='U THEN
   doup()
ELSE
   doerror() ;**** no command match
FI
```

All the 'do---'s are procedures to do the given command. If you look at the case of "chr='F'", you see that nothing is done. That's the null statement. When FIND is ready, all you need to do is put the 'dofind()' procedure in where the null statement now is, and you'll have it in the look-up table and ready for use.

5.2.3 Loops

Loops are used to repeat things, specifically statements. If, for some strange reason, you wanted to fill the screen with stars (*) you could either send out each star with a separate statement, or you could use a loop to do this for you. All you need to do is tell the loop how many times you want it to put out a single star, and it will do it (if you use the proper statement format, of course).

There are two ways to tell a loop how many times you want it to do something. You can give it an explicit number, or you can give it a conditional expression and execute the loop depending on the outcome of that expression. The FOR statement uses the first method, and both WHILE and UNTIL use the second.

What happens when you don't tell the loop how many times it should execute? What happens when the conditional expression never evaluates to a value that will stop the loop? You get what is known as an 'Infinite Loop'. There is only one way to get out of an infinite loop; you have to push the <SYSTEM RESET> key.

ACTION! approaches loops in the following manner. There is a basic loop, which, when used alone, is infinite. Then there are some loop controlling statements (FOR, WHILE, UNTIL) which limit the number of times this infinite loop executes. We'll follow the same pattern; first a discussion about the basic loop structure, followed by an in depth look at the loop controlling statements.

5.2.3.1 DO and OD

'DO' and 'OD' are used to mark the beginning and end,
repectively, of the basic loop . Everything between
them is considered to be part of that loop. As
mentioned above, a loop alone (i.e. without any loop
controlling statement) is an infinite loop, and you
must force a break out of it. Following is a program
example to illustrate the DO - OD loop. Don't worry
about the 'PROC' and 'RETURN' statements; they're just
there so that the program will compile and run
properly, and will be discussed in full in the
procedures and functions chapter (6).

Example #1:
   PROC timestwo()

      CARD i=[0],j

      DO   ;start of DO - OD loop
      i==+1   ;add 1 to 'i'
      j=i*2   ;set 'j' equal to i*2
      PrintC(i)   ;**** See the following
      Print(" times 2 equals ");PROGRAMMING NOTE for
      PrintCE(j)   ;an explanation
      OD   ;end of DO - OD loop
   RETURN

PROGRAMMING NOTE: the mixed case words (PrintC, Print,
PrintCE) you see in the example above are ACTION!
library functions and procedures. You may learn more
about them (although their jobs here are fairly
obvious) in Part VI, 'The ACTION! Library'. You will
see library routines used throughout the rest of this
chapter, so don't be alarmed; they're only there
because they do things that make the examples more
visually instructive.

Output #1:
         1 times 2 equals 2
         2 times 2 equals 4
         3 times 2 equals 6
         4 times 2 equals 8
         5 times 2 equals 10
         6 times 2 equals 12
         7 times 2 equals 14
         8 times 2 equals 16
                   :
                   :

The dot dot dot at the end of the output shows that
this will go on forever, or until you press the

<SYSTEM RESET> key. On its own, a DO - OD loop is more
or less useless, but when used in conjunction with the
loop controlling statements FOR, WHILE, and UNTIL, it
becomes one of the most useful statements available.

NOTE: hitting the <BREAK> key would also get you out of
the loop in example #1, because the loop is doing a lot
of I/O. (<BREAK> only works when doing a lot of I/O.
See Part IV, 'The ACTION! Compiler', for more informa-
tion.)

Whenever you see '<DO - OD loop>' in the formats of the
loop controlling statements, remember that it means a
loop, and that in turn means a DO - OD pair surrounding
the loop.

5.2.3.2 EXIT Statement

The EXIT statement is used to hop gracefully out of any
loop. This statement will cause program execution to
skip to the statement following the next 'OD'. Here's
an example:

Example #1:
    PROC timestwo()

        CARD i=[0],j

        DO   ;start of DO - OD loop
        i==+1   ;add 1 to 'i'
        j=i*2   ;set 'j' equal to i*2
        PrintC(i)
        Print(" times 2 equals ")
        EXIT   ;Here's the EXIT statement
        PrintCE(j)
        OD   ;end of DO - OD loop
        ;**** execution continues here after 'EXIT'
        PrintE("End of Table")
    RETURN

Output #1:
        1 times 2 equals End of Table

As you can see in the output, the statement
'PrintCE(j)' is never executed. The EXIT statement
forces execution to hop to the statement 'PrintE("End
of Table")'. EXIT isn't very useful when utilized
alone, but if you use it in conjunction with an IF
statement (i.e., make the EXIT into a conditional jump
out of the loop), it can be very useful, as the program
on the following page shows.

```
Example #2:
    PROC timestwo()

        CARD i=[0],j

        DO                  ;start of DO - OD loop
        IF i=15 THEN
            EXIT            ;EXIT in an IF conditional
        FI
        i==+1 ˙
        j=i*2
        PrintC(i)
        Print(" times 2 equals ")
        PrintCE(j)
        OD                  ;end of DO - OD loop
        ;**** execution continues here when i=15
        PrintE("End of Table")
    RETURN

Output #2:
        1 times 2 equals 2
        2 times 2 equals 4
        3 times 2 equals 6
        4 times 2 equals 8
        5 times 2 equals 10
        6 times 2 equals 12
        7 times 2 equals 14
        8 times 2 equals 16
        9 times 2 equals 18
        10 times 2 equals 20
        11 times 2 equals 22
        12 times 2 equals 24
        13 times 2 equals 26
        14 times 2 equals 28
        15 times 2 equals 30
        End of Table
```

This usage turns an infinite loop block into a finite
one. EXIT can control the execution of a loop, but is
not considered a structured loop controlling statement
because it doesn't stand on its own; that is, it is
only useful when used in conjunction with the
structured 'IF' statement.

5.2.4 Loop Controls

ACTION! has three structured statements that control
the basic DO - OD loop:

                1) FOR
                2) WHILE
                3) UNTIL

By saying that they "control the basic DO - OD loop",
we mean that they limit the number of times the
infinite loop executes, thus making it a finite loop.
Controllable loops are one of the devices that make
computers very useful. If someone told you to write
"I'll never throw spitwads again" one thousand times,
you would call that punishment, but if you told the
computer to do the same thing (with a controlled loop,
of course), it would think that the task was easy and
mundane.

Now we'll take a look at each loop controlling
statement in depth, and then go into a property of all
ACTION! structured statements: nesting.

5.2.4.1 FOR Statement

The FOR statement is used to repeat a loop a given
number of times. It requires its own special variable,
commonly called a counter. In the examples the counter
will be called 'ctr' to remind you of this, but you
could call it anything you like. The format of the FOR
statement is:

FOR <counter>=<initial value> TO <final value> {STEP <inc>}

        <DO - OD loop>

    where
        <counter>   is the variable used to keep
                         track of the number of times the
                         loop has executed
        <initial value> is the starting value of the
                         counter
        <final value>   is the ending value of the
                         counter
        <inc>   is the amount by which the
                         computer increments the counter
                         after every iteration
        <DO - OD loop>   is a DO - OD infinite loop

    NOTE: the 'STEP <inc>' is optional

Instead of trying to explain this to you using
metaphors, we'll throw a few examples at you, because
they more or less speak for themselves. Following each
is its output.

Example #1:
```
   PROC hithere()

      BYTE ctr ;counter used in FOR loop

      FOR ctr=1 TO 5    ;this FOR loop has no 'STEP', so
         DO             ;an increment of 1 is assumed.
         PrintE("Hi there")
         OD
   RETURN
```

Output #1:
```
      Hi there
      Hi there
      Hi there
      Hi there
      Hi there
```

Example #2:
```
   PROC evens()

      BYTE ctr ;counter used in FOR loop

      FOR ctr=0 TO 16 STEP 2   ;this FOR loop has a 'STEP'
         DO
         PrintB(ctr)
         Print(" ")
         OD
   RETURN
```

Output #2:
```
      0 2 4 6 8 10 12 14 16
```

Look back at the format of the FOR statement. Notice
that we said nothing about using numeric variables as
<initial value>, <final value>, or <inc>. Doing this
is legal, and allows you to make FOR loops execute a
variable number of times.

If you change the value of the variables used as
<initial value>, <final value>, or <inc> in the loop
itself, you won't change the number of times the loop
is executed. This is true because <initial value>,
<final value>, and <inc> are set with a constant value
when you enter the loop. If you do use variables, the
value used when setting these is the value the variable
had when the loop was first entered.

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If you change the value of <counter> in the loop, you
will change the number of times the loop executes,
because <counter> is a variable in the loop. It is
variable in the loop because the FOR statement itself
must change the value of <counter> every time it goes
through the loop (FOR increments <counter> by the STEP
value). Following is an example to illustrate changing
<initial value>, <final value>, and <counter> in the
FOR loop itself:

Example #3:
```
   PROC changeloop()

      BYTE ctr,
          start=[1],
          end=[50]

      FOR ctr=start TO end
         DO
         start=100  ;doesn't affect number of repetitions
         end=10           ;doesn't affect number of repetitions
         PrintBE(ctr)
         ctr==*2       ;DOES affect number of repetitions
         OD
   RETURN
```

Output #3:
```
        1
        3
        7
       15
       31
```

Below is table to show what is going on each time
through the loop. 'rep' tells which repetition the
loop is on, 'inc ctr' shows the result of the FOR loop
incrementing the value of the counter, 'Print' shows
what is printed out to the screen, and 'ctr==*2' shows
how this assignment statement changes the value of the
counter.

rep	inc ctr	Print	ctr==*2
1	---	1	2
2	3	3	6
3	7	7	14
4	15	15	30
5	31	31	62

After the fifth loop is through, the counter equals 62.
This is greater than <final value> (50), so the loop is
exited after only 5 repetitions, not 50. Manipulating
the counter within its own loop can lead to very

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interesting results, some of which might even be useful.

As promised in section 5.2.2, here's an example of a timing loop:

```
BYTE ctr

FOR ctr=1 TO 250
    DO
    ;**** here's the null statement
    OD
```

This is just used as a time-waster; something you'll use a lot if you're writing games or other programs which involve careful timing.

PROGRAMMING NOTE: If you write a FOR loop which continues to the limit of the data type of the counter (e.g., 'FOR ctr=0 TO 255' if ctr is a BYTE, or 'FOR ctr=0 TO 65535' if ctr is a CARD), the loop will be infinite because the counter can't be incremented to a value greater the the given <final value>.

5.2.4.2 WHILE Statement

The WHILE statement (and the UNTIL statement, for that matter) is used when you don't want to execute a loop a predetermined number of times. WHILE allows you to keep looping as long as a given conditional expression is 'true'. It has the form:

```
        WHILE <cond exp>
            <DO - OD loop>
```

where
            <cond exp>   is the controlling conditional
                            expression
            <DO - OD loop> is a DO - OD infinite loop

Since the evaluation of the conditional expression is done at the start of the loop, '<DO - OD loop>' might not be executed at all. This is not the case with UNTIL, as you will see later. Program examples using WHILE start on the following page.

Example #1:
```
   PROC factorials()
   ;**** This procedure will print out the factorials
   ;up to some specified number (the variable 'amt')

      CARD fact=[1],    ;the factorial of 'num'
           num=[1],     ;the counter
           amt=[6000]   ;the upper bound of testing

      Print("Factorials less than ")
      PrintC(amt)          ;prints the upper bound
      PrintE(":")          ;print a ':' and carriage return
      PutE()               ;prints a carriage return
      WHILE fact*num < amt    ;test next factorial
         DO                   ;start of WHILE loop
         fact==*num
         PrintC(num)             ;print the number
         Print(" factorial is ")
         PrintCE(fact)           ;print number's factorial
         num==+1                 ;increment number
         OD                      ;end of WHILE loop
   RETURN      ;end of PROC factorials
```

Output #1:
```
      Factorials less than 6000:

      1 factorial is 1
      2 factorial is 2
      3 factorial is 6
      4 factorial is 24
      5 factorial is 120
      6 factorial is 720
      7 factorial is 5040
```

PROGRAMMING NOTE: If you go over "Factorials less than
40000", you will discover that the compiler does no
overflow error checking, because you'll see the output
'wrap around'; that is, you'll get a number larger than
the maximum a CARD allows (65535), and start at zero
again. If you got up to, say, 66000, the output would
show $66000-65536=464$ because it went as high as it
could go, and then wrapped around. The technical term
for this kind of thing is 'overflow', and you can find
out more about it in Part IV: 'The ACTION! Compiler'.

Example #2:
```
PROC guesswhile()
;**** This procedure plays a guessing game with
;the user, using a WHILE loop to keep the game
;going

    BYTE num,           ;the number to guess
         guess=[200]    ;guess is initialized to an
                        ;impossible value.

    PrintE("Welcome to the guessing game.  I'm")
    PrintE("thinking of a number from 0 to 100")
    num=Rand(101)       ;gets the number to guess
    WHILE guess<>num
        DO                      ;start of WHILE loop
        Print("What's your guess?  ")
        guess=InputB()          ;get user's guess
        IF guess<num THEN       ;guess too low
           PrintE("Too low, try again")
        ELSEIF guess>num THEN ;guess too high
           PrintE("Too high, try again")
        ELSE                    ;guess just right
           PrintE("Congratulations!!!!")
           PrintE("You got it")
        FI                      ;end of guess testing
        OD                      ;end of WHILE loop
    RETURN      ;end of PROC guesswhile
```

Output #2:
```
        Welcome to the guessing game.  I'm
        thinking of a number from 0 to 100
        What's your guess?  50
        Too low, try again
        What's your guess?  60
        Too high, try again
        What's your guess?  55
        Too low, try again
        What's your guess?  57
        Congratulations!!!!
        You got it
```

Notice how powerful manipulating conditionals like IF
within a loop can be. It allows the computer to take
care of multiple possible outcomes every time it goes
through the loop.

5.2.4.3 UNTIL Statement

In the last section we said that a WHILE loop could
execute zero times because its conditional expression
was evaluated before loop execution began. The form of
the UNTIL statement is such that this loop always
executes at least once. After you see the form you'll
probably understand why this is so:

```
DO
<statement>
     :
     :
<statement>
UNTIL <cond exp>
OD
```

This looks like a common DO - OD loop until you get to
the statement just before the 'OD'. This UNTIL
controls the infinite loop using the outcome of the
conditional expression. If <cond exp> is 'true' then
execution will continue at the statement after the
'OD', otherwise it will loop back up to the 'DO'.
Notice that the UNTIL must be the statement directly
before the 'OD'. A program example should clarify this
somewhat:

```
#1)
   PROC guessuntil()
   ;**** This procedure plays a guessing game with
   ;the user, using an UNTIL loop

      BYTE num,        ;the number to guess
           guess       ;the user's guess

      PrintE("Welcome to the guessing game.  I'm")
      PrintE("thinking of a number from 0 to 100")
      num=Rand(101)    ;get the number to guess
      DO                          ;start of UNTIL loop
      Print("What's your guess?  ")
      guess=InputB()              ;get the user's guess
      IF guess<num THEN           ;guess too low
         PrintE("Too low, try again")
      ELSEIF guess>num THEN       ;guess too high
         PrintE("Too high, try again")
      ELSE                        ;guess just right
         PrintE("Congratulations!!!!")
         PrintE("You got it")
      FI                          ;end of guess testing
      UNTIL guess=num             ;loop control
      OD                          ;end of UNTIL loop
   RETURN        ;end of PROC guessuntil
```

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Output #1:
```
      Welcome to the guessing game.  I'm
      thinking of a number from 0 to 100
      What's your guess?  50
      Too low, try again
      What's your guess?  60
      Too high, try again
      What's your guess?  55
      Too low, try again
      What's your guess?  57
      Congratulations!!!!
      You got it
```

This is the same example as in the WHILE section, but
this time implemented using an UNTIL loop. Notice that
'guess' is not initialized in the variable declaration,
as it was in the WHILE equivalent. We can do this
because the conditional expression 'guess=num' is not
evaluated until we have gotten a guess from the user.
This is one of the advantages of the UNTIL loop, and
stems from the fact that the controlling conditional
expression is at the end of the loop. WHILE requires
evaluation of the conditional expression at the
beginning of the loop, and so requires that 'guess'
have a value.

5.2.5 Nesting Structured Statements

As mentioned in the overview of statements, structured
statements are made up of other statements, together
with some execution controlling information particular
to a given structured statement. The statements within
the structured statement may be either simple
statements or other structured statements. Putting one
structured statement inside of another is called
nesting (because one of them is 'nested' inside the
other).

In sections 5.2.4.2 (WHILE) and 5.2.4.3 (UNTIL), you
can see examples of nesting an IF statement into WHILE
and UNTIL loops. This type of nesting is very
straightforward, and needn't be discussed further.
This section will deal with multiple nesting of the
same type of structured statement (IFs inside IFs, FORs
inside FORs, etc...).

When the IF statement is nested inside itself,
confusion might seem to arise when trying to figure out
what ELSE goes with which IF as you go deeper into the
nested statements. The compiler avoids any confusion
by IF-FI pairing. A FI is paired to the first
preceeding IF that doesn't already have a FI paired to

it. For example:

```
+ IF <expA> THEN
|   + IF <expB> THEN
|   |      <statements>
|   | ELSEIF <expC> THEN ;**** ELSEIF of IF <expB>
|   |   + IF <expD>  THEN
|   |   |      <statements>
|   |   | ELSE                ;**** ELSE of IF <expD>
|   |   |      <statements>
|   |   + FI                 ;**** end of  IF  <expD>
|   + FI                 ;**** end of IF <expB>
| ELSEIF <expE> THEN ;**** ELSEIF of IF <expA>
|      <statements>
| ELSE                ;**** ELSE of  IF <expA>
|      <statements>
+ FI                 ;**** end of IF <expA>
```

The dashed lines show the IF-FI pairing; the comments
show which IF statement a particular FI or ELSEIF per-
tains to; and the indentation shows a change of levels.

The following program example contains nested FORs.
This one even does something worthwhile; it prints out
the multiplication table up to ten times ten.

```
PROC timestable()
    ;*** This procedure prints out the multiplication
    ;table up to 10 times 10

    BYTE c1,          ;*counter for outer FOR loop
         c2           ;*counter for inner FOR loop

    FOR c1=1 TO 10   ;outer loop control
        DO                ;*start of outer loop
        IF c1<10 THEN     ;*single digits need a  space
            Print(" ")    ;before  them  in  the  first
        FI                ;column
        PrintB(c1)        ;*print 1st number in column
        FOR c2=2 TO 10    ;*inner loop control
            DO                ;*start of inner loop
            IF c1*c2 < 10 THEN ;*single  digits  need 3
                Print("   ")    ;spaces
            ELSEIF c1*c2 < 100 THEN    ;*double  digits
                Print("  ")    ;need 2 spaces
            ELSE              ;*triple  digits  need 1
                Print(" ")    ;space only
            FI                ;*end of digit spacing
            PrintB(c1*c2)     ;*print the result
            OD                ;*end inner loop
        PutE()            ;*put out a carriage return
        OD                ;*end of outer loop
    RETURN      ;*end of PROC timestables
```

Output:

```
 1   2   3   4   5   6   7   8   9  10
 2   4   6   8  10  12  14  16  18  20
 3   6   9  12  15  18  21  24  27  30
 4   8  12  16  20  24  28  32  36  40
 5  10  15  20  25  30  35  40  45  50
 6  12  18  24  30  36  42  48  54  60
 7  14  21  28  35  42  49  56  63  70
 8  16  24  32  40  48  56  64  72  80
 9  18  27  36  45  54  63  72  81  90
10  20  30  40  50  60  70  80  90 100
```

As you can see from the above examples, nesting can be used to accomplish quite a bit, if you know what you're doing. Fortunately, "knowing what you're doing" doesn't take too much time, because the concept of nesting is universal to all strucured statements. Once you understand it as applied to one statement, you can apply it to all of them.

Chapter 6: Procedures and Functions

Procedures and functions are used to make your ACTION!
program more readable and usable. Almost everything we
do is a procedure or function in some way or other.
For example, look at this table:

Procedures	Functions
Washing the car	Balancing your checkbook
Doing dishes	Looking up a phone number
Driving to work	
Going to school	

What makes these procedures and functions? Well, for
each there's

   1) a group of related actions done to accomplish the task
   2) an accepted order in which these actions are done

Drying the dishes before you wash them breaks the
accepted order, and taking off your left sock is not an
action related to "Doing the dishes". We know these
things from experience, and have lumped the proper
group of actions done in the proper order into a
procedure; one which we call "Doing the dishes".

In computer languages it's the same way. You make a
group of actions that accomplish a single, large task
into a procedure or function, which you then give a
name.   When you want to execute this task, all you do
is use the procedure or function name (with some extras
we'll discuss later).   This is referred to as a
procedure or function call. The procedure or function
must have already been defined, just like in English.
(e.g., you wouldn't know what to do if someone told you
to "readjust the widget" unless you already knew the
actions required to do this.)

Now, what is the difference between procedures and
functions?   They both go through a series of ordered
steps to accomplish a task, so why two names for the
same construct?   Because they're not exactly the same
construct. Functions have an added property; they do
their task, and then return a value.

In the table at this section's beginning we see
"Balancing your checkbook" given as a function example.
Why? Well, when you balance your checkbook you go

through a series of steps to bring your records up to date, and come up with a (hopefully positive) number at the end. This number is returned and can be used to do other things (like determine the size of your next check).

If we wanted to make "Doing the dishes" a function, we could change the statement to the question "Do the dishes need doing?", hoping that the person would answer the question, and then do the dishes if required. This would get the dishes done (like the procedure), but also return a value (whether the dishes needed doing in the first place), and thus make it a function.

NOTE: Throughout the rest of this manual we will use the word "routine", instead of saying "procedure or function". Doing this makes the concepts easier to follow. When you see "procedure" or "function", it means the concept or idea being discussed is specific to that class of routines and not applicable to both classes.

6.1 PROCedures

Procedures are used to group some statements which
accomplish a task into a named block that can be called
on to do this task. To utilize procedures in ACTION!,
you must learn how to do two things:

1) declare procedures
2) call procedures

The following three sections will show you how to do
the above and give some examples to let you see
procedures in ACTION! (small pun intended).

6.1.1 PROC Declaration

The ACTION! keyword 'PROC' is used to denote the start
of a PROCedure declaration. PROCedure construction
looks quite like a group of statements with a name and
some other information at the beginning, and a funny
RETURN statement at the end. Below is a diagram of the
construction.

```
PROC <identifier>{=<addr>}({<parameter list>})
    {<variable decl>}
    {<statement list>}
RETURN
```

where

PROC	is the keyword denoting a procedure declaration
<identifier>	is the name of the procedure
<addr>	optionally specifies the starting address of the procedure (See 9.3)
<parameter list>	is the list of parameters required by the procedure (see section 6.4 for an explanation of parameters)
<variable decl>	is the list of variables declared local to this procedure (see 3.4.1 for variable declaration and 6.3 for scope of variables)
<statement list>	is the list of statements in the procedure
RETURN	denotes the end of the procedure (see next section)

NOTE: <parameter list>, <variable decl>, and <statement list> are all optional. You will probably use at least some of them, but the following would be a valid procedure declaration:

```
PROC nothing()        ;the parentheses ARE required
RETURN
```

It does nothing, but this type of "empty" procedure is useful when you are writing a program made up of many procedures. If, for example, you have written a program that calls a procedure named "dotest", but you haven't yet written "dotest", you could make it an empty procedure so you could test the rest of the program without getting an "Undeclared Variable" error.

Don't worry about '<parameter list>' and 'RETURN' in the format, because they'll be discussed later. The rest should look somewhat familiar, so we'll give an example:

```
PROC guessuntil()
;**** This procedure plays a guessing game with
;the user, using an UNTIL loop

    BYTE num,        ;the number to guess
         guess       ;the user's guess

    PrintE("Welcome to the guessing game.  I'm")
    PrintE("thinking of a number from 0 to 100")
    num=Rand(101)    ;get the number to guess
    DO                           ;start of UNTIL loop
    Print("What's your guess?  ")
    guess=InputB()             ;get the user's guess
    IF guess<num THEN          ;guess too low
       PrintE("Too low, try again")
    ELSEIF guess>num THEN      ;guess too high
       PrintE("Too high, try again")
    ELSE                       ;guess just right
       PrintE("Congratulations!!!!")
       PrintE("You got it")
    FI                         ;end of guess testing
    UNTIL guess=num            ;loop control
    OD                         ;end of UNTIL loop
RETURN         ;end of PROC guessuntil
```

This is just the program example from section 5.2.4.3, but now you understand why the PROC statement and the variable declaration section are there. As mentioned in the introduction, an ACTION! program requires a procedure declaration or a function declaration to be compilable. The above example has a procedure declaration, so it is a valid ACTION! program and, as

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such, may be compiled and run. Its output is the same
as that given in the UNTIL section, namely:

```
Welcome to the guessing game.  I'm
thinking of a number from 0 to 100
What's your guess?  50
Too low, try again
What's your guess?  60
Too high, try again
What's your guess?  55
Too low, try again
What's your guess?  57
Congratulations!!!!
You got it
```

If you look back at the above example, you'll see
'RETURN' as the last statement. We'll now cover why
it's there.

6.1.2 RETURN

RETURN is used to tell the compiler to leave the
procedure and return control to whatever called the
procedure. If your program calls a procedure,
execution will continue with the statement after the
procedure call. If you are compiling a single
procedure (or a one procedure program), control will be
returned to the ACTION! monitor.

WARNING: the compiler cannot detect a missing RETURN.
Strange and disastrous things can happen if you leave
out a RETURN. This also goes for RETURNs at the end of
functions as well.

There can be more than one RETURN in a procedure. For
example, if your procedure has an IF statement with
lots of ELSEIFs, you might want to RETURN after one or
more of the ELSEIF cases. The example on the following
page illustrates this possibility.

```
PROC testcommand()
;**** This procedure tests a command to see if it is
;valid.   Valid commands are Ø, 1, 2, and 3.  If the
;command is  none of  these,  an  error  message  is
;printed, and control is returned to whatever called
;this procedure

    BYTE cmd

    Print("Command>> ")
    cmd=InputB()
    IF cmd>3 THEN
        PrintE("Command Input ERROR")
        RETURN  ; get out before command tests
    ELSEIF cmd=Ø THEN
        <statementØ>
    ELSEIF cmd=1 THEN
        <statement1>
    ELSEIF cmd=2 THEN
        <statement2>
    ELSEIF cmd=3 THEN
        <statement3>
    FI
RETURN
```

Note the 'RETURN' after the first condition, which
tests for illegal input; You don't want to go through
all the command tests if the command isn't a valid one,
so you just print your error message and hop out of the
procedure with a RETURN.   Voila!

6.1.3 Calling Procedures

You've already seen some procedure calls, although you
probably don't know it. Almost every time we used a
library routine in an example, we were making a
procedure call. The format is simple enough:

        <identifier>({<parameter list>})

where
        <identifier>   is the name of the procedure
                            you want to call
           contains the values you want
                            to send to the procedure as
                            parameters

Here are a couple of examples (don't worry about the parameters now, a whole section is devoted to them later):

```
PrintE("Welcome to Joe's Deli, the only")
PrintE("computerized deli in the world.")

factorials()

guessuntil()

BYTE z
CARD add
signoff(add,z)
```

Of course you must already have declared the procedures 'factorials', 'guessuntil', and 'signoff' before using them here. 'PrintE' is a library procedure, so it's not declared by you but is declared in the ACTION! library. Notice that the parentheses are required even when the procedures have no parameters. When a procedure you call has parameters, the call must have no more parameters than the procedure declaration (but it may have fewer). See section 6.4 for a discussion of parameters.

6.2 FUNCtions

As mentioned in the overview of procedures and
functions, the fundamental difference between the two
is that functions return a value. This makes the way
in which they are declared and called somewhat
different from procedure declarations and calls. Since
functions return a numeric value, they must be used
where a number is valid (e.g., in arithmetic
expressions).

6.2.1 FUNC Declaration

Declaring a function is similar to declaring a
procedure, except that you must be able to show both
what type of number the function returns (BYTE, CARD,
or INT) and what that number is. The format is:

```
<type> FUNC <identifier>{=<addr>}({<parameter list>})
    {<variable decl>}
    {<statement list>}
RETURN (<arith exp>)
```

where

<type>	is the fundamental data type of the value the function returns
FUNC	is the keyword denoting a function declaration
<identifier>	is the name of the function
<addr>	optionally specifies the starting address of the function (see 9.3)
<parameter list>	is the list of parameters required by the function (see section 6.4 for an explanation of parameters)
<variable decl>	is the list of variables declared local to this function (see section 3.4.1 for variable declaration, and and 6.3 for scope of variables)
<statement list>	is the list of statements in the function
RETURN	denotes the end of the function
<arith exp>	is the value you wish returned from the function

As in procedure declarations, <parameter list>,
<variable decl>, and <statement list> are all optional.
In the case of procedures, leaving them out was useful

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only in one instance. In functions, doing this sort of thing has another (more worthwhile) use, as the following example shows:

Example #1:
```
   CARD FUNC square(CARD x)
   RETURN (x*x)
```

This function takes a CARD number and returns its square. Don't worry about the parameter list, as we will discuss it a little later. It was mentioned above that the value returned is in the form of an arithmetic expression. In example 1, you can see this being done in "(x*x)".

In the following example, the arithmetic expression used to return a value is simply a variable name.

Example #2:
```
   BYTE FUNC getcommand()
   ;**** This function reads in a command number, and
   ;then passes it out if it's 1 through 7 inclusive.
   ;Otherwise, the function will reprompt the user.

      BYTE command,      ;this variable holds the command
           error         ;set to 1 if an error is found

      DO
      Print("COMMAND>   ")
      command=InputB()
      IF command<1 OR command>7 THEN    ;invalid command
         error=1
         PrintE("Command Error:  Only 1-7 valid.")
      ELSE               ;valid command
         error=0
      FI
      UNTIL error=0      ;exit loop if command is valid
      OD
   RETURN (command)
```

NOTE: the parentheses around <arith exp> are always required in the RETURN statement.

The above is a simple example: Functions can be used to do quite complicated operations, but even the most convoluted functions must follow the format outlined in this section.

6.2.2 RETURN

As you probably noticed in the format of the FUNCtion declaration, the RETURN isn't used in the same way as in PROCedure declarations. In functions it is followed by (<arith exp>). This feature allows a function to return a value. If you tried to put (<arith exp>) after the RETURN in a procedure declaration, you would get an error, because procedures can't return a value.

Although there are dissimilarities between RETURNs in functions and procedures, there is one convenient similarity: you may have more than one RETURN in both procedures and functions. The following example shows usage of muliple RETURNs in a function:

> Scenario: Example #1 in the function declaration section (6.2.1) returned the square of a CARD, but it did no checking for overflow. If you squared 256 you would get 65536, 1 greater than the maximum CARD value allowed. There are two ways to fix this problem:

> 1) Require that the number being squared be of BYTE type, thus making it impossible to enter a number greater than 255.
> 2) Check for overflow in the function itself

The following example illustrates the second method:

```
CARD FUNC square(CARD x)
;**** This function tests 'x' for overflow, and
;returns its square if valid.  IF invalid,  the
;function prints an error message and returns 0.

    IF x>255 THEN  ;number would cause overflow
        PrintE("Number too big")
        RETURN (0)  ;return a zero
    FI
RETURN (x*x)    ;return 'x' squared
```

See how easy it is? The use of multiple RETURNs can come in very handy when you are testing a lot of different conditions, each requiring that a different value be returned.

NOTE: As mentioned in section 6.1.2, the compiler can't tell if you leave out a RETURN, so you must make sure you have one.

6.2.3 Calling Functions

You have already seen two examples of function calls.
They can be found in section 5.2.4.2 (WHILE), example
#2, and section 5.2.4.3 (UNTIL), example #1. If you
look at those programs, you'll see the lines:

```
num=Rand(101)
guess=InputB()
```

The first is an example of calling a function that
requires parameters, and the second an example of
calling one without parameters. Both 'Rand' and
InputB' are library functions. 'Rand' returns a random
number between 0 and the number you give it (in the
above case, 101) minus one. 'InputB' reads a byte
value from the default device (the screen). Notice
that both of them return a value. Because this value
must go somewhere or be used somehow, function calls
must be used in arithmetic expressions. In the above
two cases, the arithmetic expressions consist of the
function call only and are used in assignment
statements (a valid use of arithmetic expressions).

Function calls can be used in any arithmetic
expression, with one exception:

> Functions calls may NOT be used in an
> arithmetic expression when that expression is
> used as a parameter in a routine call or
> declaration.

> Example:
```
x=square(2*Rand(50))   ;INVALID
         ^^^^^^^^^
```

Here are some examples of valid function calls:

```
x=5*Rand(201)
c=square(x)-100/x
IF ptr<>Peek($8000)
chr=uppercase(chr)
```

'Peek' and 'Rand' are library functions, so they
needn't be declared by you, but 'square' and
'uppercase' are user written functions, and so they
must be declared before they are called here.

PROGRAMMING NOTE: although it is not recommended, you
can call functions as though they were procedures. If
you do this, the value returned is ignored.

6.3 Scope of Variables

The term "Scope of a Variable" is used to express the range of a variable's legitimacy. To help you understand what this means, let's apply the concept of "Scope" to a more familiar situation: the English language.

Below is a table of British English words, followed by their American English equivalent:

British	American
BONNET	HOOD
LORRY	TRUCK
LIFT	ELEVATOR
FAG	CIGARETTE

Each pair of words means the same, but the words' scopes are different. "Bonnet" (when used to mean the moveable cover over an auto's engine) is legitimate only when used in countries that speak the King's English. "Hood", on the other hand, is valid only in countries that speak American English. Hence they have ranges of legitimacy, or Scope. The words in the left column could be considered "global" to British English in the sense that any average Brit would understand what was meant by each word, and the words in the right column could be considered "global" to American English because everyone who speaks American English would associate each word with its intended meaning.

Enough of global scope; now we need to talk about "local" scope. Scope is local if it is a specific subset of some global scope. For example, the word "neat" has many different local scopes within the "global" American English language:

1) "Wow, that movie was NEAT!"
2) "Gertrude keeps the NEATest house I've ever seen."
3) "Bartender, I'll have my scotch NEAT."

In different situations "neat" can mean different things (i.e., the meaning is local to the situation), and these meanings don't overlap.

Variables in ACTION! also have an associated scope. A variable's scope determines where it may and may not be used just as, in the above analogy, a word's scope determines where it may and may not be used.

The following program is a concrete example of variable scope:

Example #1:
```
MODULE          ;we're going to declare some variables
                ;as global

CARD numgames=[0],  ;number of games played
     goal=[10],     ;number of guesses to beat
     beatgoal=[0]   ;number of times you've beaten goal

PROC intro()
;**** This procedure puts the leadin to the game on
;the screen.

    CARD ctr

    PrintE("Welcome to the guessing game.  I'm")
    PrintE("thinking of a number from 0 to 100.")
    PrintE("All you have to do is type in your")
    PrintE("guess when I ask you to.")
    PutE()
    PrintE("I'll keep track of how many games")
    PrintE("you've played, and tell you how")
    PrintE("many times you've guessed the number")
    PrintE("in fewer tries than your goal, but")
    PrintE("first you have to give me your goal.")
    PutE()
    Print("  Type your goal here --> ")
    goal=InputC()
    FOR ctr=0 to 2500  ;a delay loop, to give the
        DO             ;sense  of  real-time to the
        OD             ;player.
    Put($7D)       ;clear the screen
RETURN          ;end of PROC intro


PROC tally()
;**** This procedure prints out the current tally

    Print("You have played ")
    PrintC(numgames)
    PrintE(" games,")
    Print("and in ")
    PrintC(beatgoal)
    PrintE(" of those you")
    PrintE("have beaten your goal of")
    PrintC(goal)
    PrintE(" guesses.")
    PutE()
RETURN          ;end of PROC tally
```

```
PROC playgame()

    CARD numguesses,   ;the number of guesses
         ctr           ;counter used in delay loop

    BYTE num,          ;the number to guess
         guess         ;the user's guess

    PrintE("I'm picking my number...")
    FOR ctr=0 TO 4500  ;delay used to make the user
        DO             ;think the computer is picking
        OD             ;a number
    PutE()
    PrintE(" O.K., here we go!")
    PutE()
    num=Rand(101)      ;get the number to guess
    numguesses=0       ;set number of guesses to 0
    DO                          ;start of UNTIL loop
    Print("What's your guess?   ")
    guess=InputB()              ;get the user's guess
    numguesses==+1              ;add 1 to number of guesses
    IF guess<num THEN           ;guess too low
        PrintE("Too low, try again")
    ELSEIF guess>num THEN       ;guess too high
        PrintE("Too high, try again")
    ELSE                        ;guess just right
        PrintE("Congratulations!!!!")
        Print("You got it in ")
        PrintCE(numguesses)
        IF numguesses<goal THEN
            beatgoal==+1
        FI
    FI                          ;end of guess testing
    UNTIL guess=num             ;loop control
    OD                          ;end of UNTIL loop
RETURN        ;end of PROC playgame

BYTE FUNC stop()
;**** This function finds out if the player wants
;to play another game.

    BYTE again

    PrintE("Do you want to play")
    Print("another game? (Y or N)   ")
    again=GetD(1)     ;get player's response
               ;from K: to avoid getting a RETURN as
               ;the first guess of the next game.
    PutE()
    IF again='N OR again='n THEN      ;doesn't
        RETURN (1)                    ;want to play
    FI
RETURN (0)  ;end of FUNC stop
```

```
PROC main()

    Close(1)              ;just for safety's sake
    Open(1,"K:",4,0)      ;open K: to read only
    intro()               ;print out the introduction
    DO
    numgames==+1          ;increment total number of games
    playgame()            ;play the game once
    tally()               ;show tally of games thus far
    UNTIL stop()          ;doesn't want to play anymore
    OD
    PutE()
    PrintE("Come play again soon")
    Close(1) ;close K:
 RETURN        ;end of PROC main
```

The following table shows how this program uses
variables. It gives the variable name, its scope, its
availability and use in each routine:

> KEY:
> A = variable Available for use in routine
> U = variable Used in routine

VARIABLE NAME	SCOPE	PROC playgame	PROC intro	PROC tally	FUNC stop	PROC main
numgames	global	A	A	A U	A	A U
goal	global	A U	A U	A U	A	A
beatgoal	global	A U	A	A U	A	A
numguesses	local	A U				
num	local	A U				
guess	local	A U				
ctr	local	A U				
again	local				A U	
ctr	local		A U			

You can see that that the global variables are
available for use in every one of the routines, whereas
the local variables are available only in the routine
in which they are declared. Notice that there are two
local variables called 'ctr', one in PROC playgame, and
the other in PROC intro. Although they have the same
name, these two variables are not the same, just as
'neat' meaning "clean" and 'neat' meaning "undiluted"
were not the same earlier. The two 'ctr's have
different local scopes (because they are declared in
two different procedures).

6.4 Parameters

Parameters allow you to pass values into a routine.
You may wonder why this is necessary, since you could
use global variables for passing values into and
between routines. Well, there are two reasons that
parameters exist:

        1)   They make your routines capable of multi-
              purpose use.
        2)   They allow you to manipulate variable values
              within a routine without changing the value
              of any global variable.

We'll discuss each of these advantages separately,
following the above order; but first we should give the
format of a parameter list, for those of you who
already know all about parameters.

** Parameters in PROC or FUNC declarations:

        ({<variable decl>}|:,<variable decl>:|)

   where
     <variable decl>   is a variable declaration, except
                        that it may not contain the
                        '=<addr> or [<const>]' option

   Examples:

        PROC test(BYTE chr,num,i, CARD x,y)
        INT FUNC docommand(INT cmd, CARD ptr, BYTE offset)
        CARD FUNC square(BYTE x)
        PROC jump()

** Parameters in PROC or FUNC calls:

        ({<arith exp>}|:,<arith exp>:|)

   where
     <arith exp>   is an arithmetic expression

   Examples:

        test(cat,dog,ctr,2500,$8D00)
        sqr=square(num)
        jump()
        x=docommand(temp,var,'A)

NOTE: A routine may have up to 8 parameters. Use any
more, and you will get a compiler error.

We need to do some explaining now. The following example will show you how to use parameters, and clarify the first of the two advantages to using parameters.

The following function checks to see if the BYTE variable 'chr' is a lowercase letter. If it is, the function will return the uppercase of it. Otherwise the function will simply return 'chr'. Notice that we don't declare 'chr' anywhere. We'll discuss where it should be declared after the example.

```
    BYTE FUNC lowertoupper()

    IF chr>='a AND chr<='z THEN   ;$20 is the offset
        RETURN (chr-$20)      ;between lower and upper
    FI                    ;case in the ATASCII set
    RETURN (chr)
```

Now we must decide where to declare 'chr'. We already know that we could declare it global, or just local to 'lowertoupper'. If we declare it locally, how will we give it a value? There seems to be no use to having it local, because then the function itself would have to give the variable a value, and that's not what we want the function to do. We want it to be able to call 'lowertoupper' a form similar to

```
              chr=lowertoupper()
```

and have the function test 'chr' and make it uppercase if necessary. So we won't declare it local. How about declaring it global? That would do what we wanted, because now the 'chr' in the function call and the 'chr' in the function itself would be the same global variable. There's only one drawback to declaring 'chr' as a global variable: every time we wanted to use 'lowertoupper', we would get the uppercase of 'chr'. If we want to uppercase the variable 'cat', we would have to do the following:

```
                chr=cat
                chr=lowertoupper()
                cat=chr
```

This could get very tiresome if you wanted to uppercase a lot of different variables. Also, if you wanted to use 'lowertoupper' in another program, you would have to declare a global variable 'chr' there too.

What if we declared 'chr' as a parameter to the
function? "HOW...?" you ask. Here's how:

```
BYTE FUNC lowertoupper(BYTE chr)    ;<- the parameter
                                    ;declaration
    IF chr>='a AND chr<='z THEN
       RETURN (chr-$20)
    FI
RETURN (chr)
```

"But now how do we call it now?" Easy. All you have
to do is give it the variable you want tested as a
parameter. Examples:

```
            chr=lowertoupper(chr)
            cat=lowertoupper(cat)
            var=lowertoupper('a)
```

Making 'chr' a parameter to the function allows you to
use it for testing any variable in any program, because
'lowertoupper' now stands on its own. It uses no
variables declared elsewhere (i.e., global variables),
and yet you can give it a variable to test. We have
overcome the pitfalls of declaring 'chr' either locally
or globally. Tah dah! This is what we meant by
"multipurpose".

The second advantage to using parameters is more
difficult to illustrate, but we're going to make it as
clear as possible, again by using an example. The
following procedure takes two CARD type numbers,
divides the first by the second, and prints out the
result:

```
PROC division(CARD num,div)

    num==/div         ;changes num to num/div
    PrintC(num)       ;print out num
RETURN
```

And now to use the 'division' procedure in a program:

Example #1:
```
   PROC main()

      CARD ctr,
           number=[713]

      FOR ctr=1 TO 10
         DO
         PrintC(number)
         Print("/")
         PrintC(ctr)
         Print(" = ")
         division(number,ctr)
         PutE()
         OD
   RETURN
```

Output #1:
```
        713/1 = 713
        713/2 = 356
        713/3 = 237
        713/4 = 178
        713/5 = 142
        713/6 = 118
        713/7 = 101
        713/8 = 89
        713/9 = 79
        713/10 = 71
```

Notice that 'number' remains constant, although 'num' changes. The value of 'number' is passed into 'num' when the procedure is called, but the value of 'num' is not passed back into 'number' when the procedure is exited. If the value of 'num' were passed back into 'number', the output would be:

```
        713/1 = 713
        713/2 = 356
        356/3 = 118
        118/4 = 29
        29/5 = 5
        5/6 = 0
        0/7 = 0
        0/8 = 0
        0/9 = 0
        0/10 = 0
```

The flow of information through parameters is one-way. Information can be sent to a routine through parameters, but information generally may not be sent out using parameters. If you want to send a single

value back from a routine, make that routine a
function, and then you can send it back in the function
RETURN statement. If you want to send out more things,
you can use global variables or you can pass pointers
as parameters (see 9.5).

A Note On Parameter Pairing:
   When you call a routine that has parameters, the
   first parameter you give in the call will go into
   the first variable in the list of parameters in
   the routine declaration, the second will go into
   the second, and so on.... You can pass fewer
   parameters than the routine requires, but no more.
   For example, if there are 5 parameters in the
   declaration, you could pass the routine 0 to 5
   parameters. This allows you to write routines
   that require a variable number of parameters,
   depending on the job it must do. HINT: if you do
   this, the first parameter should probably be the
   number of parameters being passed.

A Note On Type Compatibility:
   If the value you pass as a parameter and the value
   expected by the routine are of different data
   types, you won't get a compiler error because the
   ACTION! compiler insures parameter type
   compatibility. For example, if you pass a CARD
   when the procedure wants a BYTE, the LSB of the
   CARD will be put into the BYTE variable, and the
   procedure will carry on as though you had passed
   it a BYTE (see Part IV for more info).

A Note On Parameter Variable Types:
   All of the following are valid as parameters:

       1) Fundamental Data Type variables
       2) Array, Pointer, and Record References
       3) Array, Pointer, and Record Names

   In the third case, the names are used as pointers
   to the first element, the value, or the first
   field in the named variable.

6.5 MODULE

MODULE is a very simple directive. Its form is:

MODULE

It simply tells the compiler that you wish to declare some more global variables. It is useful when you have written a large program in sections, each with its own global variables. If you say MODULE at the beginning of each section, then the compiler will add all the global variables to the global variable table.

A program need not have a MODULE directive, because the compiler assumes one MODULE directive at the beginning of the program, whether you put it there or not.

The declaration of global variables must come either immediately after a 'MODULE', or at the very beginning of the program (which is really right after the 'MODULE' assumed by the compiler).

Chapter 7: Compiler Directives

Compiler directives are different from the standard language commands in that they are executed at compile-time rather than run-time. A language command, such as an assignment statement (see section 5.1.2) is evaluated after you tell the ACTION! Monitor to RUN your program, when your program has control over what is being done. A compiler directive is evaluated when you tell the monitor to COMPILE your program, so the compiler, not your program, has control. The ramifications of this will soon become apparent.

7.1 DEFINE

The DEFINE directive is very similiar to the editor's substitution (<CS> S) command, except that it does the substitution at compile time. To clarify this, we first need to show the format:

    DEFINE <ident>=<str const>[,<ident>=<str const>}

where
         <ident>   is a valid identifier
         <str const>   is a valid ACTION! string constant
                        (That is, with surrounding double
                        quotes)

DEFINEs are not really used in generating any object code when the program is compiled, but are used to clarify ACTION! source programs. The compiler substitutes <str const> for <ident> every time <ident> is used in a program. For example, when you compile a program with the line

    DEFINE size = "256"

in it, the compiler will replace every occurence of 'size' with '256'. This allows for some interesting options (and problems if misused!). Since DEFINE will replace any string, you can change the keywords themselves! If you don't like the keyword CARD, you could change it to, say, FROG with this command:

    DEFINE FROG = "CARD"

Now whenever you compile the program, every time the compiler sees 'FROG', it will think to itself, " Oh, he really means CARD, so I'll just put that in instead."

Here are some more examples to let you become thoroughly familiar with the form:

```
DEFINE liston = "SET $49A=1"
DEFINE begin = "DO", end = "OD"
DEFINE one = "1"
```

NOTE: Don't forget that the string constant must have double quotes around it (see section 3.2).

To better show you what DEFINE does and doesn't do, here's a table showing the effects of a DEFINE on different program parts.

statement	comments
DEFINE four = " 4 "	the directive
PrintBE(four)	prints '4' with EOL
; four score and	converts 'four' to '4'
; four-score and	does not alter 'four-score'
PrintE("four score")	does not replace inside quotes

7.2 INCLUDE

The INCLUDE directive allows you to include other programs into the program being compiled. Suppose you have a program named 'IOSTUFF.ACT' that does input/output functions and you want to use the I/O routines it offers in some other program you're writing now. All you need to do is put the following command in the program you're writing:

INCLUDE "D1:IOSTUFF.ACT"

NOTE: The file specifier must have double quotes around it.

The above statement must come before you use any of the I/O routines in the file 'IOSTUFF.ACT'. Note that this example assumes that the diskette with 'IOSTUFF.ACT' on it is in disk drive #1. If you don't specify a device with your file name, the compiler assumes the device is "D1:". You can INCLUDE files from any readable device (i.e., "P:" isn't valid). Here are some more examples:

```
INCLUDE "D2:IOLIB.ACT"
INCLUDE "PROG1.DAT"
INCLUDE "C:"
```

NOTE: Most operating systems require that the file specifiers be in uppercase.

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A useful feature of the INCLUDE command is that you can
have an INCLUDE in a program which you are already
INCLUDEing (i.e., it can be nested). ACTION! allows
you to nest it to a maximum of 6 levels, but peripheral
devices and the operating system have other limits.
When the OS limits are ignored, error # 161 (too many
files open) occurs. The cassette limit is 1 INCLUDE,
and the disk drive limit is 3 INCLUDEs. If no program
is currently in the ACTION! editor buffer, then the
maximum number of levels of INCLUDE commands is reduced
by one.

7.3 SET

The SET directive is used to modify the computer's RAM
(Random Access Memory). SET pokes a new value into a
specified memory location at compile time. In most
cases, this command is used for changing Editor and
Compiler options from a user program, but it can be
used to modify user, operating system, and hardware
variables as well. The format of the SET command is:

                SET <address> = <value>

NOTE: <address> and <value> must be compiler constants.

The result of the SET statement is to set memory
location <address> to <value>. If <value> is greater
than 255, then memory locations <address> and
<address>+1 are assigned <value>. This occurs because
255 ($FF) is the biggest decimal number that can fit
into one byte, so any number greater than this requires
two bytes for storage.

Examples:
        SET $600=64   ;sets address $600 equal to 64
        SET max=16   ;sets max=16
        SET 10000=$FFFF ;sets 10000 and 10001 to $FFFF
        SET $CF00=cat   ;sets $CF00 and $CF01=@cat

        DEFINE add="$7000"
        SET add=$42

The last example shows a DEFINEd numeric constant used
in a SET statement. Since DEFINEs are constants at
compile time, they are valid in the SET directive.
Just make sure you DEFINE the constant before you use
it in a SET statement.

NOTE: do not confuse the compile-time effect of SET
with the similar run-time effect of Poke and PokeC.

Chapter 8: Extended Data Types

The extended data types make the ACTION! language more
flexible than many others available on the ATARI. Just
as the structured statements manipulate groups of
simple statements thereby extending the capabilities of
the ACTION! language, the extended types manipulate
groups of fundamental type variables and extend the
language capabilties even more.

The three extended data types in ACTION! are:

                    1) Pointers
                    2) Arrays
                    3) Records

We will discuss each separately, following the order of
the above list.

8.1 POINTERs

Pointer.   Sounds like the thing the weatherman uses to
show us a place on his map. Well, it is. In the
context of ACTION!, "pointer" means something very
similar.

Pointers contain a memory address, and so point to a
memory location. You can change the value of a pointer
and make it point to a new place, just like moving the
weatherman's pointer to another place on the map. The
big difference is that he points to cities or states,
whereas ACTION! pointers can point to BYTE, CARD, or
INT values.

Somehow we have to let the compiler know what type of
value we want a given pointer to point to. The
declaration section will show you how to do this.

After we've gone over the method used to declare a
pointer, we'll show you how it can be used. This is
done in the manipulation section through the use of
program examples.

8.1.1 Pointer Declaration

The format used to declare a pointer looks quite
similar to the format of fundamental data type variable
declarations, except that we tell the compiler that the

variable is a pointer, and not just a fundamental data
type:

        <type> POINTER <ident>{=<addr>}|:,<ident>{=<addr>}:|

where
        <type>   is the fundamental type of the
                        information the pointer points to.
        POINTER   is the keyword used to show that
                        the variables declared are
                        pointers.
        <ident>   is the name of the pointer variable
        <addr>   tells where in memory you want the
                        pointer to point to initially. It
                        must be a compiler constant.

Because a pointer variable actually contains an
address, it must be able to take on values ranging from
0 to 65535 ($0 to $FFFF), since an ATARI with 64k of
memory has that many separate memory locations.
Pointers are stored as a two-byte unsigned numbers (in
LSB, MSB order) to allow this range. That means that
they are stored as CARDs, except that they can be
interpreted as addresses.

Since the use of pointers is dealt with in the next
section, we'll just give some sample pointer
declarations, instead of whole program examples:

        BYTE POINTER ptr   ;declares ptr as a pointer
                                ;to a BYTE value

        CARD POINTER cpl   ;declares cpl as a pointer
                                ;to a CARD

        INT POINTER ip=$8000   ;declares ip as a pointer
                                ; to an INT, and points it
                                ;to memory location $8000

8.1.2 Pointer Manipulation

Pointers can be used to manipulate a variety of things
in ACTION! for the simple reason that they can easily
be made to point to different memory locations. This
makes cataloguing and tabulating information very easy.

The program on the following page is just a simple
example to give you an idea of what a pointer actually
does. It will introduce the '^' address operator used
with pointers; after the example we'll discuss the '^'
in depth.

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Example #1:
```
PROC pointerusage()

    BYTE num=$E0,              ;declare and place two
         chr=$E1              ;BYTE variables.
    BYTE POINTER bptr   ;declare a pointer to BYTE
                        ;type.

    bptr=@num         ;make bptr point to num.
    Print("bptr now points to address ")
    PrintF("%H",bptr);prints out num's address.
    PutE()
    bptr^=255         ;puts 255 into the location bptr
                      ;points to (i.e., into num).
    Print("num now equals ")
    PrintBE(num)      ;shows that 255 really went into
                      ;num.
    bptr^=0           ;puts 0 into num
    Print("num now equals ")
    PrintBE(num)      ;shows that num equals 0 now.
    bptr=@chr         ;makes bptr point to chr now.
    Print("bptr now points to address ")
    PrintF("%H",bptr);prints out chr's address, so we
    PutE()            ;know that bptr really changed.
    bptr^='q          ;puts 'q into the location bptr
                      ;points to (i.e., into chr).
    Print("chr now equals ")
    Put(chr)          ;shows that chr really equals 'q
    PutE()
    bptr^='z          ;changes chr to 'z
    Print("chr now equals ")
    Put(chr)          ;shows that chr is equal to 'z
    PutE()
RETURN
```

Output #1:
```
    bptr now points to address $E0
    num now equals 255
    num now equals 0
    bptr now points to address $E1
    chr now equals q
    chr now equals z
```

Notice that we use the '^' operator when we want to put
a value into the place the pointer points to. So the
line "bptr^=0" in the above example is the same as
saying "num=0", because 'bptr' is pointing to 'num' at
that time. Although we don't use it in the above
example, pointer references can be used in arithmetic
expressions, as follows:

$$x=ptr^\wedge$$

Also notice that "PrintF("%H", bptr)" is valid. What this means is that 'bptr' can be accessed as a CARDinal number as well as an address. This is useful when debugging your program, because you can find out where the pointer is pointing easily.

8.2 ARRAYs

Arrays allow you to manipulate lists of variables by making each variable in the list accessible using only the array name and a subscript. The variables in the list must be of the same data type, and only the fundamental data types are allowed. The array name tells which array you want and the subscript tells which element of that array you want. The subscript is just a number, so what you're really saying when you reference an array element is, "I want the nth element of array x," where 'n' is the subscript and 'x' is the array name.

In the following section we will discuss the internal representation of an array. After that we'll show you how to declare arrays and manipulate them, and then we'll talk about the limitations of arrays in ACTION!.

8.2.1 Array Declaration

Declaring arrays is easy in ACTION!, but that doesn't mean that you don't have much control over what's going on. There are many options you can use to define different characteristics of the array, including its address, its size, and even its initial contents. Because of all these options, the format looks somewhat cluttered, but the examples should clear up any confusion.

        <type> ARRAY <var init>|:,<var init>:|

where
        <type>   is the fundamental type of the
                        elements of the array.
        ARRAY   is the keyword denoting an array.
        <var init>   is the information required to
                        declare one variable as an array of
                        <type> data type elements.

<var init> has the form:

    <ident>{(size)}{=<addr> | [<values>] | <str const>}

where

<ident>	is the name of the variable
<size>	is the size of the array, and must be a numeric constant.
<addr>	is the address of the first element of the array, and must be a compiler constant.
[<values>]	sets the initial values of the elements of the array. Each value must be a numeric constant.
<str const>	sets the initial values of the elements of the array to the string constant, with the first element being the length of the string.

We warned you that it was cluttered! But now to organize some of this clutter with some instructive (hopefully) examples:

    BYTE ARRAY a,b ;declares two arrays with BYTE
                    ;elements without sizes declared

    INT ARRAY x(10) ;declares 'x' as an INT array,
                    ;and dimensions its size

    BYTE ARRAY str="This is a string constant" ;this
             ;declares "str" as a BYTE array, and
             ;fills it with a string constant

    CARD ARRAY junk=$8000   ;declares 'junk' as a
             ;CARD array, which starts at $8000 in
             ;memory, without any size implied

    BYTE ARRAY tests=[4 7 18] ;declares 'tests' as
             ;a BYTE array, and fills in its values.

PROGRAMMING NOTES: You should dimension the size of an array whenever possible, but there are some instances where you can't or needn't:

1) When you don't know how big it's going to be (i.e., as in a routine parameter, when you don't know how big an array is going to be passed).
2) When you are filling the array in the declaration (using either the '[<values>]' or '<str const>' construction), and you aren't planning to add to the array.

Also, remember that the first byte of a string constant contains the length of that string. So, to make an string longer, first you must change the length byte (which is the zeroeth element of the array containing the string).

8.2.2 Internal Representation

The internal representation of an array is very much like that of a pointer. This is because the array name is actually a pointer to the first element of the array. The array itself is simply a contiguous group of cells, each containing an array element. The size of a cell is determined by the data type of the elements: one-byte cells for BYTE type, two-byte cells for both CARD and INT types. However, having the array name be a pointer leads to some very interesting ramifications, as shown in examples 2 through 4 of the the following section.

8.2.3 Array Manipulation

Using and manipulating arrays is not very difficult once you know how to declare the array and reference its elements. You already know how to declare arrays, so now we'll show you how to reference elements:

```
Example #1:
   PROC reftest()
      BYTE x
      BYTE ARRAY nums(10)

      FOR x=0 TO 9       ;although nums is ten elements
                         ;long, the subscripts run from
                         ;0 to 9, not 1 to 10
         DO
         nums(x)=x+'A    ;xth element of nums is assigned
                         ;the value x+'A
         Put(nums(x))    ;put out xth element of nums as
                         ;a character
         Print(" ")      ;put a space between the chars.
         OD
      PutE()
   RETURN

Output #1:
      A B C D E F G H I J
```

There are two array references in the above program --
'nums(x)' in the assignment statement, and 'nums(x)' as
a parameter to the 'Put' library procedure. They, and
all other array references, have the form:

        <ident>(<subscript>)

where
        <identifier>   is the name of the array you want
                        to reference.
        <subscript>   is the number of the element in
                        that array, and is an arithmetic
                        expression.

As mentioned in the comment explaining the FOR loop,
array subscripts do not start at 1, as you might
expect. The first element in array 'cat' is 'cat(0)',
not 'cat(1)'. This might seem strange, but you get
used to it very quickly.

Example #2:
    PROC changearray()

        BYTE ARRAY barray

        barray="This is string 1."
        PrintC(barray)   ;prints the CARD 'barray' contains
        Print(" ")
        PrintE(barray)   ;prints the string 'barray points
        barray="This is string 2."   ;to (with an EOL)
        PrintC(barray)
        Print(" ")
        PrintE(barray)
    RETURN

Output #2:
        10352   This is string 1.
        10414   This is string 2.

EXAMPLE 2 COMMENTS: Notice from the output that the
        address to which 'barray' is pointing changes.
        Reassigning the whole array (when doing it using
        string constants) does not put the new string into
        the memory space occupied by the old one, but
        rather allocates new space for the new string, and
        then changes the value of 'barray' to point to the
        starting address of the new string. The old
        string is still in memory, but nothing is pointing
        to it any more, so it is inaccessible.

Notice that "PrintE(barray)" is valid, because 'barray' points to a valid string constant, which is the type of parameter the PrintE library procedure requires. Pretty sneaky!!

Example #3:
```
   PROC equatearrays()

      BYTE ARRAY a="This is a string constant",
                 barray

      barray=a
      PrintE(a)
      PrintE(barray)
   RETURN
```

Output #3:
```
      This is a string constant
      This is a string constant
```

EXAMPLE 3 NOTES: All this program does is show you that you can equate two arrays simply by making them point to the same memory location; in this case it's a string constant they're both pointing to.

You might have noticed that we have not done anything like

```
   BYTE ARRAY a=['A ' 's 't 'r 'i 'n 'g]

   PrintE(a)
```

That's because the above won't work. Remember that string constants are different from simple strings because their first byte contains their length, so procedures that expect a string constant will balk when you attempt to send them anything else.

And now for a program that uses all the applications of
arrays which we have discussed.

Example #4:
SCENARIO: You have a program that only gives error
numbers when the user makes an error, and you want
it to print out error messages as well. You could
do this using arrays, as in the following program.
We will discuss how the program works after the
program itself.

```
PROC doerror(BYTE errnum)
;****    This procedure reads in the error number and
;prints out the related message. See the discussion
;following the program for an explanation of how  it
;works.

    BYTE ARRAY errmsg  ;the message printed out

    CARD ARRAY addr(6) ;holds the addresses of the
                       ;error messages

    addr(0)="Illegal command"       ; |
    addr(1)="Illegal character"      ; |      See
    addr(2)="Bad File Name"          ; |    EXAMPLE 4
    addr(3)="Number Too Large"       ; | NOTES for an
    addr(4)="Wrong Type Of Number"   ; | explaination
    addr(5)="Unknown Error"          ; |
    errmsg=addr(errnum)  ;puts the error message asso-
    Print("ERROR #")            ;ciated with 'errnum' in
    PrintB(errnum)              ;'errmsg' and prints it
    Print(":  ")                ;out after the error num-
    PrintE(errmsg)              ;ber itself
    PutE()
RETURN  ;**** End of procedure doerror

PROC main()
;****    This  procedure is just a dummy used to call
;the above procedure, using all valid error numbers,
;to show that the table works.

    BYTE error

    FOR error=0 TO 5
        DO
        doerror(error)
        OD
RETURN  ;**** End of procedure main
```

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Output #4:
        ERROR #0:   Illegal command
        ERROR #1:   Illegal character
        ERROR #2:   Bad File Name
        ERROR #3:   Number Too Large
        ERROR #4:   Wrong Type Of Number
        ERROR #5:   Unknown Error

EXAMPLE 4 NOTES: The way in which we fill the CARD
    array in this example is strange (how can you fill
    a CARD array element with a string?) but is
    perfectly valid because the string constant itself
    is not being assigned to the array element; rather
    its address is. This makes each element of the
    array an implicit ` pointer to a string. All we
    have to do is assign the value of the proper array
    element (i.e., the one pointing to the needed
    error message) to the BYTE array 'errmsg' thus
    making 'errmsg' point to the proper message. Then
    we just print out the message.

We understand that the above program is very confusing
until you completely understand the concept of arrays
and their internal representation, but it is here so
that you can see some of the advanced capabilities of
arrays.

8.3 Records

Records are constructions which allow you to group
together some pieces of information,which, although
related in some way, are not of the same type. Your
driver's license is an example of a record.   It has
your name, photo, address, and license number all
together. These pieces of information belong together
in that they all describe you to some degree, but they
are of different types.   Your name is a character
string, your photo is a picture, and your address is
made up of both numbers and characters, as is your
license number. Of course the ACTION! language doesn't
support all these types. Instead, it groups together
only the types of information the compiler understands:
the fundamental data types.

8.3.1 Declaring Records

ACTION! records manipulate the fundamental data types by creating a new data type composed of one or more of the fundamental types. Then you declare variables of that type just as you declare variables of type BYTE, INT, or CARD. This allows you to declare as many variables of one record type as you want, without having to redeclare the format of the record type every time.

The next section (8.3.1.1) shows how to create a record data type, and section 8.3.1.2 demonstrates how to declare variables of a predefined record type.

8.3.1.1 The TYPE Declaration

Without further ado we'll present the form used to declare a record data type:

```
     TYPE <ident>=[<var decls>]
```

where

TYPE	is the keyword denoting the definition of a record type.
<ident>	is the name of that record type.
<var decls>	are valid variable declarations, as in section 3.4.1, except that the '=<init info>' option shown there is forbidden.

At this point, an example would probably help:

```
     TYPE rec=[BYTE bl,b2    ;two BYTE fields first,
               INT il        ;then one INT field,
               CARD cl,c2,c3 ;then three CARD fields
               BYTE b3]      ;ending with a BYTE
```

This needs some explanation so we'll go through it piece by piece:

TYPE rec
      We are defining a new data type called 'rec'
BYTE bl,b2
      The first two fields of this type are of BYTE type, and are called 'bl' and 'b2'.
INT il
      The third field is of type INT, and its name is 'il'.

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CARD c1,c2,c3
        The fourth through sixth fields are CARD type,
        and are named c1, c2, and c3, respectively.
BYTE b3
        The seventh and final field of the record type
        'rec' is of BYTE type and is called 'b3'.

Notice that there are no commas between the different
variable declarations (between the CARD and BYTE
declarations, for example). If you do put commas in,
the compiler will try to read the fundamental type
words (CARD, BYTE, INT) as variables, and that will
cause a compiler error.

8.3.1.2 Declaring Variables

The last section showed you how to declare a record
type, and this section will show you how to declare
variables of a given record type. The format is very
similar to that used when declaring variables of
fundamental types, but it does have its peculiarites:

        <ident> <var>{=<addr>}|:,<var>{=<addr>}:|

where
        <ident>   is the name of the record type.
        <var>   is a varible whose data type is
                       declared to be the record type.
        <init info>   is information used to set some
                       attributes of the variable.
        <addr>   is the address in memory where you
                       want the variable to be located.
                       It must be a numeric constant.

Here's an example using the record type declared in the
previous section. After the example is an explanation
of what's going on.

    TYPE rec=[BYTE b1,b2   ;same TYPE declaration .
              INT il   ;used in the previous
              CARD c1,c2,c3 ;section
              BYTE b3]d   ;ending with a BYTE

    rec   arec,   ;declares arec as data type 'rec'
          brec=$8000   ;declares brec as type 'rec',
                       ;and places it at address $8000

EXPLANATION:

rec

Shows that the following variables are of data type 'rec', just as BYTE, INT, and CARD (when used in variable declarations) show that the following variables are of those types.

arec

Declares 'arec' to be a variable of data type 'rec'.

brec=$8000

Declares 'brec' to be a variable of data type 'rec', and places it at memory location $8000.

So now that you know how to declare a record data type, and then declare variables of that type, it's time to find out how to reference and manipulate records.

8.3.2 Record Manipulation

To learn how to manipulate records, we first must must learn how to reference a field within a record. The following program does just that, using the period ('.') operator. We'll discuss its usage after the program itself.

Example #1:
```
   PROC recordreference()
   ;**** This procedure reads in some information about
   ;an employee, and then prints it out to let the em-
   ;ployee know it's correct.

      TYPE idinfo=[BYTE level,        ;employee's level
                  CARD idnum,         ;his I.D. number
                  entry_year]         ;year he started
      idinfo rec       ;declaring 'rec' as record type
                       ;'idinfo'
      Print("What is your I.D. number?  ")
      rec.idnum=InputC()        ;get his I.D. number
      Print("What is your employment level (A-Z)?  ")
      rec.level=GetD(7)         ;get his employment level
      Print("In what year did you start working here?  ")
      rec.entry_year=InputC()   ;get his entry year
      PrintE("O.K.  Here's what I have:")
      PutE()              ;   +
      Print("I.D. #  ")   ;   |   Prints
      PrintCE(rec.idnum)  ;   |   out the
      Print("Level:  ")   ;   |   information
      Put(rec.level)      ;   |   the
      PutE()              ;   |   employee
      Print("Entry year:  ")  ; |  put in
      PrintCE(rec.entry_year) ; +
   RETURN       ;end of PROC recordreference
```
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Output #1:
        What is your I.D. number? 4365
        What is your employment level? L
        In what year did you start working here? 1978

        O.K. Here's what I have:

        I.D. # 4365
        Level: L
        Entry year: 1978

The '.' is used to notify the compiler that you are
making a record reference (and is only valid in record
references). From the above program example you can
see that the format of a record reference is:

        <record name>.<field name>

Note that <field name> and <record name> are defined in
different declaration statements, as shown in the
previous section. <field name> is defined in the TYPE
declaration, when you define the fields of a record
type, whereas <record name> is defined in a variable
declaration, when you declare the variable to be of a
record type.

8.4 Advanced Use of the Extended Types

The extended data types seem to be limited by the fact
that they may only operate on the fundamental types;
that is, you cannot have arrays of records, an array
field in a record, etc. However, there are ways to get
around these limitations, as seen in example 4, section
8.2.3. In that example we created an array of pointers
by using the elements of a CARD array as pointers, not
cardinal numbers. In this section we'll demonstrate
some other ways to get more out of the extended types,
including a program using records with array fields,
and another program which uses an array of records.

"But you just said that was illegal." It is illegal if
you try it directly, but, as we mentioned above, there
are ways around, over, under, and between the literal
definition of the extended types.

The following example will fill an undimensioned array
with a list of records. The way it does this is simple
once we define a "virtual record", because the array is
actually a BYTE array with blocks of bytes being
grouped into virtual records.

A virtual record is not a record in the sense that we

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declare it as a record type. It is a record only
because we access a section of memory as though it were
a record, although it is really just a string of bytes.
All we do is fill a BYTE array so that it looks like
contiguous records, not bytes. This is done by
declaring a record data type, and then declaring a
pointer to that data type. Then we manipulate the
array in blocks the size of one record by making the
pointer jump through the array in leaps the size (in
bytes) of one record. We will expand on this in the
technical discussion following the example itself.

Example #1:

```
MODULE          ;declaring some global variables

    TYPE idinfo=[CARD idnum,    ;employee's I.D. number
                       codenum ;his access code
                BYTE level]    ;his employment level

    BYTE ARRAY idarray(1000) ;enough   space to hold
                               ;200 records.
    DEFINE recordsize="5"

    CARD reccount=[0]

PROC fillinfo()
;**** This procedure will take some information
;on a given employee, put it into an array of
;records using a pointer to the record type and
;indexing that pointer in the array.  This pro-
;cess will continue as long as the user desires
;to input more information.

    idinfo POINTER newrecord

    BYTE continue

    DO
    newrecord=idarray+(reccount*recordsize)
    Print("I.D. number?   ")
    newrecord.idnum=InputC() ;get I.D. number
    Print("Employment level (A-Z)?   ")
    newrecord.level=GetD(7)   ;employment level
    Print("Access code? ")
    newrecord.codenum=InputC()          ;get secret code
    reccount==+1
    PutE()     .
    Print("Input another record (Y or N)? ")
    continue=GetD(7)
    PutE()
    UNTIL continue='N OR continue='n
    OD
RETURN
```

PROGRAMMING NOTE: This   procedure   does not make sure
you're within the bounds of the array, nor does ACTION!
itself,   so   you   might want to add a boundary checking
routine.

EXAMPLE 1 NOTES: There are a couple things this   proce-
    dure   does   that   require   a detailed explanation,
    including these procedure lines:

        DEFINE recordsize="5"

        idinfo POINTER newrecord

        newrecord=idarray+(reccount*recordsize)

        newrecord.XXX=xxx

        reccount==+1

    We'll   go   through   these one by one.   This should
    not only explain the   statements   themselves,   but
    should   also   clarify   the   concept we're using to
    accomplish the array of records.

    DEFINE recordsize="5"
        This DEFINE is used as the "jump"   size   when
        we   are   going through the array.   The record
        type 'idinfo' is 5 bytes long (2 CARDS and   1
        BYTE),   so   this   will allow us to go through
        the array in 5-byte   leaps.   Every   time   we
        leap   like this we will skip over one record,
        thus eliminating the   possiblity   of   writing
        one record partially on top of another.

    idinfo POINTER newrecord
        Here we are defining a pointer   to   the   type
        'idinfo'.   We   can   fill fields of a virtual
        record in the array simply   by   pointing   the
        pointer   to   the   first   field   in one of the
        virtual records, and then using   the   pointer
        in   a   record   reference   to   access a single
        field.

    newrecord=idarray+(reccount*recordsize)
        This assignment makes the   pointer   point   to
        the end of the array.   It does this by adding
        the   space   occupied by all the other records
        to the starting address of   the   array.   The
        space   occupied   by   all the other records is
        simply the   number   of   records   ('reccount')
        times the size of each record ('recordsize').

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newrecord.XXX=xxx
            'XXX' is one of the field names of the record
            type, and 'xxx' is the corresponding input
            function used to fill the array. Since we
            made 'newrecord' point to the end of the
            array, we can start filling in the new
            record. We can use the pointer in the record
            reference because we declared it as a pointer
            to that record type.

    reccount==+1
            Here we are simply incrementing the variable
            that keeps track of the number of records
            currently in the array. We do this because
            we just put another one in.

In example #4 we will use this array we've filled to
verify the information typed in by someone trying to
gain entrance into a restricted area (by making sure
they key in the proper secret code), but we'll have to
remember to access the array as an array of records,
using the same format in which the array was filled,
otherwise some strange problems will arise.

Before we go on to show the program that looks into the
filled array, let's first modify the records a little
bit. We'll add one more field which will contain the
employee's name in the form:

    LastName, FirstName

To do this we must somehow make the field an array. Or
must we? Instead, let's simply add a BYTE field to the
end of the record type, and then change the DEFINE
directive to make the size given each record increase.
If we increase it by 20, suddenly we have 25 byte
reserved for 6 bytes of field (2 CARDs and 2 BYTEs).
Then we just put the string in the extra space, by
accessing the last field (our new BYTE field) and
putting in a string instead of a byte. The string
can't be longer than 19 characters (recall the first
byte of a string is its length), so we'll have to make
sure the string is short enough. Without further ado,
we'll move onto the extended version of the 'idinfo'
procedure, complete with strings.

Example #2:
```
MODULE        ;declaring some global variables

    TYPE idinfo=[CARD idnum,   ;employee's I.D. number
                      codenum  ;his access code
                 BYTE level,   ;his employment level
                      name]    ;first letter of name

    BYTE ARRAY idarray(1000) ;enough  space to hold
                             ;40 records.
    DEFINE recordsize="25",
           nameoffset="5"

    CARD reccount=[0]

PROC fillinfo()
;**** This is simply the modified version of the
;previous example.

    idinfo POINTER newrecord

    BYTE POINTER nameptr       ;pointer to 'name' field

    BYTE continue

    DO
    newrecord=idarray+(reccount*recordsize)
    Print("I.D. number?  ")
    newrecord.idnum=InputC() ;get I.D. number
    Print("Employment level (A-Z)?  ")
    newrecord.level=GetD(7)   ;employment level
    Print("Access code? ")
    newrecord.codenum=InputC()          ;get secret code
    nameptr=newrecord+nameoffset ;point 'nameptr' to
    PrintE("Employee's name?")    ;start of name field
    Print("(form: Last, First) ")
    InputS(nameptr)  ;read name into name field
    reccount==+1
    PutE()
    Print("Input another record (Y or N)? ")
    continue=GetD(7)
    PutE()
    UNTIL continue='N OR continue='n
    OD
RETURN
```

EXAMPLE 2 NOTES: As in the previous example, there are
     some program lines which need explanation,
     including:

               nameoffset="5"

               BYTE POINTER nameptr

               nameptr=newrecord+nameoffset

               InputS(nameptr)

Before discussing the lines individually, let's go
over the method used to put the name into the
array of records. First of all, we need to find
where to put the name once we've read it in, then
we need to figure out a way to read the name in.
The explanations of the above statements show you
how we do it:

nameoffset="5"
          This DEFINEs the distance you have to go into
          a single record to get to the first byte of
          the string, and is used when getting the
          pointer to the string to point to the right
          position.

BYTE POINTER nameptr
          This pointer is used to point to the first
          byte of the 'name' field in a record.

nameptr=newrecord+nameoffset
          Here we are setting the value (i.e., where we
          the pointer to point) of the pointer
          'nameptr'. It's set by taking the address of
          the start of the record ('newrecord') and
          adding the offset distance to the first byte
          of the string storage location.

InputS(nameptr)
          This is used to read in the name, and uses
          'nameptr' as a pointer to the storage
          location, just as shown in section 8.2.3
          (example 2), except that we are using a
          pointer instead of an array name (which is
          just a pointer to the first element anyway).

Now that we have a way to put the records into the
array, we need a way to search through the array record
by record when looking for a match. The following is a
function designed to do just that. It will access the
array as using the record format of example 2, and
return the address of the start of the first record

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with an 'idnum' matching the one passed in as a parameter. If no match is found, then Ø is returned as the address. Note that this function uses variables declared in the global statement section (i.e., after the MODULE) of the previous example.

Example #3:
```
CARD FUNC findmatch(CARD testidnum)

    idinfo POINTER seeker    ;points to each record
                             ;in turn to do test
    BYTE ctr ;used as a counter in the FOR loop

    FOR ctr=Ø TO (reccount-1) ;minus one because we
        DO                   ;start at Ø, not 1
        seeker=idarray+(ctr*recordsize) ;index record
        IF seeker.idnum=testidnum THEN ;test for an
            RETURN (seeker)  ;I.D. match and return
        FI                   ;if found
        OD
RETURN (Ø)  ;no match found. End of FUNC findmatch
```

This function needs very little explanation, since it's straightforward compared to the previous examples. All we do is go to every record and test its 'idnum' field for a match with 'testidnum'. Now let's turn the past two examples into a true program by putting a shell around it.

Example #4:
```
MODULE          ;declaring some global variables

    TYPE idinfo=[CARD idnum,   ;employee's I.D. number
                      codenum ;his access code
                 BYTE level,   ;his employment level
                      name]    ;first letter of name

    BYTE ARRAY idarray(1ØØØ) ;enough space to hold
                             ;40 records.
    DEFINE recordsize="25",
           nameoffset="5"

    CARD reccount=[Ø]



;****************************************************
;
;          continued on following page
;
;****************************************************
```

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```
PROC fillinfo()
;**** Here's the array filling procedure again

    idinfo POINTER newrecord

    BYTE POINTER nameptr       ;pointer to 'name' field

    BYTE continue

    DO
    newrecord=idarray+(reccount*recordsize)
    Print("I.D. number?   ")
    newrecord.idnum=InputC() ;get I.D. number
    Print("Employment level (A-Z)?   ")
    newrecord.level=GetD(7)   ;employment level
    Print("Access code?  ")
    newrecord.codenum=InputC()          ;get secret code
    nameptr=newrecord+nameoffset ;point 'nameptr' to
    PrintE("Employee's name?")   ;start of name field
    Print("(form: Last, First)  ")
    InputS(nameptr)   ;read name into name field
    reccount==+1
    PutE()
    Print("Input another record (Y or N)? ")
    continue=GetD(7)
    PutE()
    UNTIL continue='N OR continue='n
    OD
RETURN

CARD FUNC findmatch(CARD testidnum)

    idinfo POINTER seeker     ;points to each record
                              ;in turn to do test
    BYTE ctr ;used as a counter in the FOR loop

    FOR ctr=0 TO (reccount-1) ;minus one because we
        DO                    ;start at 0, not 1
        seeker=idarray+(ctr*recordsize) ;index record
        IF seeker.idnum=testidnum THEN ;test for an
            RETURN (seeker)     ;I.D. match and return
        FI                    ;if found
        OD
RETURN (0) ;no match found.  End of FUNC findmatch


;****************************************************
;
;          continued on following page
;
;****************************************************
```

```
PROC main()
;**** This procedure controls the whole shebang

    idinfo POINTER recptr      ;pointer to a record

    BYTE POINTER nameptr       ;pointer to 'name' field

    CARD id_num,       ;I.D. number input by user
         code_num,     ;code number input by user
         keyid=[65535] ;I.D. number allowing loop exit

    BYTE mode ;controls the operation mode

    PrintE("Startup....")
    PrintE("What operation mode?")
    PrintE("X = expand list of employees")
    PrintE("A = alert/test input mode")
    Print(">> ")
    mode=InputB()     ;read mode
    IF mode='A OR mode='a THEN ;anything but A or a
        fillinfo()      ;will go to X mode
    ELSE         ;interrogation routine
       DO    ;loop start
       Print(" Employee I.D. number >> ")
       id_num=InputC() ;get I.D. number
       IF id_num=keyid THEN  ;enables exit from
           EXIT          ;the infinite loop
       ELSE  ;a normal I.D. number (i.e., not keyid)
           recptr=findmatch(id_num)    ;look for I.D. match
           IF recptr=0 THEN    ;no match
               PrintE("DO NOT PASS")
           ELSE    ;an I.D. match
               Print(" Code Number >> ")
               code_num=InputC() ;get access code
               IF recptr.codenum=code_num THEN   ;a match
                   nameptr=recptr+nameoffset
                   Print("I.D. # ")         ; +
                   PrintCE(recptr.idnum);   |   print
                   Print("Level:  ")    ;   |   out
                   Put(recptr.level)    ;   |   known
                   Print("Name:   ")    ;   |   info.
                   PrintE(nameptr)      ; +
                   PutE()
                   PrintE("O.K. TO PASS")
               ELSE    ;code does not match
                   PrintE("DO NOT PASS")
               FI  ;end of access code testing
           FI  ;end of I.D. number verification
       FI  ;end of 'keyid' check
       OD  ;end of infinite loop
    FI   ;end of 'IF mode=.....
    PrintE("System Shutdown...")
RETURN ;end of PROC main

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```

All the main procedure does is go through a series of checks to determine what needs to be done at any given point. The nested IFs are somewhat confusing, but they are lined up (that is, indented the same amount) so you can do IF-FI paring by placing a ruler vertically on the page and sliding it back and forth to change levels of nesting.

Chapter 9: Advanced Concepts

This chapter deals with some techniques the experienced
programmer might find useful. Thus far, we have
limited our discussion of the ACTION! language to a
study of the language with respect to itself; that is,
without reference to the rest of the computer. Most of
this chapter is devoted to interfacing ACTION! to
information external to ACTION! itself, including
operating system routines and system variables.

9.1 Code Blocks

Code blocks allow you to include machine code in your
program. When the compiler sees a code block, it will
put the values in the block into the code generated,
just as though it were code generated by the compiler.
No checks are made, so we don't recommend that you use
code block unless you know quite a bit about assembly
and machine language.

The format for a code block is:

        [<value>|: <value>:|]

where
        <value>   is one of the values in the code block.
                  It must be a compiler constant (see
                  section 3.2). If it is greater than
                  255, then it is stored in LSB, MSB
                  order.

Examples:
        [$40 $0D $51 $F0 $600]

        BYTE b1,b2,b3
        ['A b1 342 b3 4+$A7]

        DEFINE on=1
        [54 on on+'t $FFF8]

Code blocks are useful for including small machine code
routines, but it's too much trouble to insert a large
one. If you want to use a lot of machine code
routines, see section 9.4 for some hints.

9.2 Addressing Variables

In sections 3.4.1, 8.1.1, and 8.2.1 (Fundamental,
POINTER, and ARRAY variable declarations) we showed

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that a variable's address could be specified when that
variable was declared, but we didn't really make use of
that option. We didn't even explain the usefulness of
doing this.

This option allows you to declare an ACTION! variable
which has the same address as any hardware register.
Then you can manipulate graphics and sound directly,
change operating system characteristics, etc.... To
illustrate the advantages of this, we're going to
present a graphics program which makes the background
color change and scroll. To do this we can't use the
normal (shadow) color registers, because they're only
looked at every T.V. frame. Instead, we'll directly
manipulate the hardware color registers. In this way
we can change the background color during one frame.
In fact, we can do it 12 times (and so get 12 colors in
graphics Ø). We have to make sure that we don't change
colors in the middle of a scan line, so we'll make use
of the hardware variable WSYNC, which tells when a scan
line is done, and the next one has not yet begun. The
variable VCOUNT tells how many scan lines have been put
out, and we use it to time the scrolling.

Example #1:
PROC scrollcolors()

```
    BYTE wsync=54282,   ;the "wait for sync" flag
         vcount=54283,  ;the "scan line count" flag
         clr=53272,     ;hardware register for background
         ctr,chgclr=[Ø], ;a counter and a color changer
         incclr         ;increments color luminance

    Graphics(Ø) ;set graphics Ø
    PutE()
    FOR ctr=1 TO 23 ;print out demo message
        DO
        PrintE("A DEMO OF SHIFTING BACKGROUND COLORS")
        OD
    Print("A DEMO OF SHIFTING BACKGROUND COLORS")
    DO  ;start of infinite scrolling loop
    FOR ctr=1 TO 4
        DO
        incclr=chgclr ;set base color to increment
            DO                ;start of UNTIL loop
            wsync=Ø           ;waits for end of scan line
            clr=incclr        ;change displayed color
            incclr==+1        ;change luminance
            UNTIL vcount&128  ;end of screen test
            OD                ;end of UNTIL loop
        OD                ;end of FOR loop
    chgclr==+1     ;change the base color
    OD  ;end of infinite scrolling loop
RETURN ;end of PROC scrollcolors
```

9.3 Addressing Routines

The concept behind specifying the address of a routine
is similar to that of specifying the address of a
variable. Only the reason behind the concept changes.
In the last section we talked about using Atari system
registers directly by addressing an ACTION! variable
to the proper location. Because you can define a
routine's address, you can make direct calls to OS and
hardware routines directly, and do your own
manipulation of I/O. The method used will be discussed
in the following section, because this method applies
to all machine language routines, whether written by
you, resident on the OS, or resident in the ROMs.

9.4 Assembly Language and ACTION!

ACTION! allows you to make calls to machine language
routines very easily. There are only two requirements:

You need to know the starting address of the
routine

The routine must end with an 'RTS' (if you want to
get back to ACTION!)

For assembly language programmers these are not diffi-
cult requirements to fill.

"What about parameters?" "Yes" is the answer. You can
even send parameters to machine language routines. The
compiler stores parameters in this way:

Address	nth byte of parameters
A register	1st
X register	2nd
Y register	3rd
$A3	4th
$A4	5th
:	:
:	:
$AF	16th

And now for an example:

```
PROC CIO=$E456(BYTE areg,xreg)
;**** Declaring the OS procedure CIO.  'xreg' will
;contain the iocb number times 16, and 'areg' is a
;filler, so the number won't go into register A
;(CIO expects it in X reg.)


PROC readchannel2()
;**** This procedure will open channel 2 to the
;given file name, and call CIO to read 'buflen' bytes

    DEFINE buflen="$2000"  ;length of the buffer array

    BYTE ARRAY filename(30), ;the file name array
               buffer(buflen)  ;the buffer array

    BYTE iocb2cmd=$362       ;iocb 2's command byte

    CARD iocb2buf=$364,      ;iocb 2's buffer start address
         iocb2len=$368       ;iocb 2's buffer length

    PutE()
    Print("File name >> ")
    InputS(filename) ;get the filename
    Open(2,filename,4,0) ;open channel 2 for read only
    iocb2cmd=7        ;'get binary record' command
    iocb2buf=buffer   ;set iocb buffer to our buffer
    iocb2len=buflen   ;set iocb buffer length
    CIO(0,$20)        ;*****  the call to CIO  *****
    Close(2)          ;closing channel 2
RETURN
```

See how easy it is? For those of you with an extensive
set of assembly language routines, this ability of
ACTION! allows you to use them in a high level
language, where building the framework of a program is
easy.

9.5 Advanced Use of Parameters

In section 6.4 we discussed parameters and their usage,
mentioning that you couldn't pass a value out of a
routine using a parameter. Well, that was a little
white lie. You can pass values out through parameters
if you use pointers. All you do is create a pointer
which points to the variable you really want to pass
into a routine, and pass the pointer instead. Then,
when you access what the pointer is pointing to, you
are really accessing the variable you wanted to pass.
You can then change the value of that variable using a
pointer reference.

This method involves some indirection (i.e., using a pointer to a variable instead of the variable itself), but is very efficient and useful in some cases, as the following example shows.

Example #1:

```
BYTE FUNC substr(BYTE ARRAY str,sub BYTE POINTER errptr,notfound)

;**** This function will search 'str' looking for the
;substring 'sub'. If it's found, the function returns
;the index onto the string. If the substring is long-
;er than the main string an error is returned via
;pointer. If the substring isn't found, that is re-
;turned via another pointer.

   BYTE ARRAY tempstr  ;holds temporary substring for test

   BYTE ctr1,  ;outer loop counter
        ctr2   ;inner loop counter

   IF sub(0)>str(0) THEN   ;substring bigger than string
      errorptr^=1
   ELSE
      FOR ctr1=1 TO str(0) ;loop to check string
         DO
         IF sub(1)=str(ctr) THEN ;testing 1st characters
            tempstr(0)=sub(0)   ;dimension tempstr
            FOR ctr2=1 to sub(0)  ;fill tempstr
               DO
               tempstr(ctr2)=str(ctr2+ctr1-1)  ;fill tempstr
               OD
            IF SCompare(tempstr,sub)=0 THEN   ;compare 2 strings
               RETURN (ctr1)   ;return index if equal
            FI
         FI ;end of testing 1st characters
         OD ;end of FOR loop
   FI
   notfound^=1  ;didn't RETURN in loop, so no match found
RETURN (0) ;end of FUNC substr
```

Now, when we want to call this we must use the form:

```
<index>=substr(<string>,<substring>,<errptr>,<nofindptr>)
```

where <index>   is the index into <string> where
                  'substring' starts.
       <string>   is the main string
       <substr>   is the substr we want to find in
                  the main string
       <errptr>   is a pointer to a byte error flag
       <nofindptr> is a pointer to a byte 'substring
                  not found' flag

This kind of parameter manipulation takes some practice
if you're not used to the concept of pointers, but is a
quick and easy way get more information passed out of a
routine without having to resort to using global
variables. This means that the routine remains
"multipurpose", as discussed in section 6.4

Part YV: The ACTION! Compiler

Part V: The ACTION! Compiler

Chapter 1: Introduction

Atari BASIC offers you great convenience in that you
can write a program in a somewhat English-like
language, then immediately test that program without
going through any other steps. This twofold advantage
is gained at the expense of requiring that each command
on each line be figured out by a special program
(called the BASIC interpreter) at the time of
execution.

ACTION! is somewhat more sophisticated. It requires
that your program be figured out by a special program -
called a compiler - before the actual execution of your
program. This requires an intermediate step between
your entry of the program and its execution by the
computer. The step is technically known as "the
compile". During the compile, the ACTION! compiler
analyzes your program on a line-by-line basis. Your
program is converted into a different language (called
machine language) with storage for both global and
local variables. The converted program can then be
executed by your Atari, running at a speed much greater
than that of the interpreted Atari BASIC.

1.1 VOCABULARY

This chapter refers to several terms which you first
learned about in Part IV. Those terms are listed here,
with each term briefly defined:

term	comments
<ident>	any valid identifier
<value>	any valid hex or decimal value
<compiler constant>	evaluates <ident>'s address
<address>	memory location

1.2 Compiler Directives

The compiler directives are discussed in depth in part
IV, chapter 7, and little more need be added here.   We
simply remind you that the compiler directives are
executed at compile time, not run time), so do not use
them when you want to change an operational parameter
while your program is running.

In this chapter we'll discuss how the the ACTION!
Compiler allocates memory space for your compiled
program, its variables, its routines, and its symbol
tables.

When called, the first thing the ACTION! Compiler does
is to decide where to put the code it will generate as
it compiles your ACTION! source program. It does this
by looking at memory location 14. The CARD value this
and the following location contain gives the address of
the start of free memory. This address will vary,
depending on the size of the Editor buffer (see
appendix B). Unless you specify otherwise, the
compiler will put your compiled code in memory starting
with address. To tell the compiler where you want your
program compiled, give the following two commands to
the Monitor right before you compile:

        SET 14=<address>
        SET $491=<address>

where
        <address> is the starting address for the com-
                  piled code.

2.1 Comments, SET, DEFINE

Neither comments, the SET directive, nor the DEFINE
directive generate any machine code. This is because
they do not do anything at run time, and so are not
required.

2.2 Variable Allocation

Information on variables is stored in two different
locations by the ACTION! Compiler - in the code itself
and in the symbol table. The symbol table is discussed
later.

Variables are stored in front of the machine code where
they are used. Some variables are declared before the
first routine is entered. These variables (called
global variables) can be used by any succeeding
routine. They need no additional declaration within
the routine.

The allocated variables are assigned space according to
the definition of the basic data types. The following

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table should help your understanding of data allocation.

data type	allocated	comments
BYTE	1 byte	fundamental type
CHAR	1 byte	fundamental type
CARD	2 bytes	fundamental type
INT	2 bytes	fundamental type
ARRAY	fundamental type size times number of elements	extended type
TYPE	sum of sizes of fundamental types, as given in declaration	extended type
string	all characters in the string plus a preceding byte to note length	each string is allocated separately even if set equal to the same identifier

2.3 Routines

The compiler allocates space for routines (procedures and functions) following that space allocated to the declared global variables. The variables declared local to a given routine precede the executable language statements in that routine. Program text (statements within procedures and/or functions) is evaluated and converted directly into machine code.

2.4 INCLUDEd Programs

Programs can be INCLUDEd at any place in the program. Of course, the INCLUDEd text must not conflict with the text currently being processed. The things to watch out for are conflicting identifiers and out-of-context insertions. When errors are detected in the INCLUDEd text, they are usually displayed in the message area. The error # is always shown in the Monitor's command line and the bell sounds.

2.5 Additional global variables - MODULE

Additional global variables, arrays, and records can be added, as needed, through the use of the MODULE key word. The variables are assigned space following the last previous routine. The identifiers are also included in the compiler's global symbol table.

2.6 Symbol Tables

The ACTION! Compiler maintains two symbol tables -- one for the global variables and one for the local variables from the last-compiled routine. The symbol tables are accessible from the ACTION! Monitor through the '?', '*', and SET commands (see Part III). They are also used by the ACTION! Compiler whenever a variable's address is required.

The Compiler allocates 8 memory pages (2K) for these tables, located right at the top of available memory. Because they are placed there, you can wipe them out if you run a program which changes into a graphics mode which requires more memory than graphics 0. This means that you won't be able to go back to the Monitor during program execution and look at the values in your variables. The Compiler will have no record of their existence since you just overwrote them.

The options menu offers you several ways to enhance or
alter the performance of the ACTION! compiler. The
various options are discussed here and in part III.
The options are also summarized in Appendix G.

Increasing compiler speed:

You can gain at least a 30% improvement in
compilation speed by using the options menu to
turn off the screen display during both disk I/O
and program compilation. Simply press 'N<RETURN>'
to the 'Screen?' prompt in the options menu.

NOTE: this also turns off the screen for other
ACTION! system functions, so you should turn the
display back on after you have finished compiling.

Turning the bell off:

When you are debugging a new program and have lots
of errors, such as typographical errors, you might
want to turn the bell off. Simply press
'N<RETURN>' to the 'Bell?' prompt in the options
menu.

Making the Compiler case sensitive:

Sometimes, particularly as you get more
sophisticated in your programming style, you might
desire that the compiler help you in your
programming by reminding you whenever you forget
to enter an ACTION! key word in upper case.   You
also might wish to benefit from the increased
flexibility of using different or mixed cases in
your identifiers.   You can do both by pressing
'Y<RETURN>' to the options menu prompt 'Case
sensitive?'.

Use of this option is not necessary to successful
ACTION! programming.   However, it is useful as an
aid to documentation and in providing a much
greater diversity in identifiers.

Listing the compiled code:

You can command the Compiler to list each program
line as it is evaluated. This may seem
unnecessary because most errors which occur are
noted and displayed on the screen during the
compiling process. However, you might have a long
program which includes routines from other sources
(remember the INCLUDE command?). If this is so,
then you might never be able to get the source
code together for a complete listing otherwise.
You can get such a listing, and even redirect it
to the printer (see part VI, section 7.9). To
enable the listing, press 'Y<RETURN>' to the
'List?' options menu prompt.

4.1 Overflow and Underflow

The ACTION!   Compiler does no checks for mathematical
overflow or underflow. "What is overflow and underflow
anyway?" They are opposite sides of the same coin.

If you have a BYTE varaible which currently equals 255,
and you add 1 to it, you won't get 256 (because a
single byte can only contain values up to 255), you'll
get Ø. Similarly, if you are using the decimal system,
and only have two digits of display, you can   run into
the same problem if you add 1 to 99. You know that it
equals 1ØØ, but you only have two digits of display, so
you see "ØØ".

Underflow is the exact opposite of this.   If you
subtract 1 from Ø, you get 255.

As mentioned in part IV, section 4.2, some of the
mathematic operators result in a specified type of
output, so you can sometimes avoid the above problems
by making use of these automatic type changes.

Likewise, shift operations can · cause overflow and
underflow.   A shift of the contents of a variable
produces similar (but not identical) results to those
achieved by multiplying or dividing by 2.

4.2 Type Compatibility and Boundary Checking

You must also be careful because the ACTION! compiler
supports no boundary checking of simple variables or
ARRAYs.   This is deliberately done in order to allow
you more flexibility in your data manipulation.   The
price for this freedom is increased vigilance. You
must set up and maintain your own procedures for
checking boundary limits and the error-handling
responses. This is another good place for a standard
set of subroutines which can be INCLUDEd.

4.3 Channel 7 Restriction

When you enter the ACTION! system, it opens channel 7 for reading from the keyboard (K:). You may use this channel for this purpose, but do not alter its attributes by reOpening or Closing it.

NOTE: if you do make use of channel 7 (and assume that its already open), your programs will not run without the ACTION! cartridge.

4.4 Available space

You might be working on a big program and suddenly find that you are out of space. When this happens, you can do one of three things, depending on what you are doing at the moment when the error appears.

If you are Editing:

> Immediately save your file (<CTRL><SHIFT>W), go to the Monitor, and reboot the system (BOOT). Then you may go back to the Editor and read your file back in.

If you are Compiling:

> Go to the Editor and save your program. Then go back to the Monitor, reboot the system, and Compile your program from the storage device (disk, cassette, etc.).

Part VI: The ACTION! Library

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Part VI: The ACTION! Library

Chapter 1: Introduction

The ACTION! library makes it possible for you to do a
lot of common I/O and graphics routines without having
to write them first. The ACTION! cartridge contains
almost 70 prewritten routines which you can call as
though they were routines written by you.   This
convenience can save you quite a bit of time and effort
whether you are a beginning or advanced programmer.

1.1 Vocabulary

Most of the vocabulary used in this part has been
defined previously, but there are two terms we'll use
often which require some discussion - IOCB and channel.

IOCB stands for "Input Output Control Block". The CIO
(Central I/O) uses IOCBs to perform I/O functions. The
ACTION! library I/O routines set up an IOCB to tell
the CIO what it (the routine) wants done, and then
makes a direct call to CIO.

The IOCBs are numbered (0 - 7). When you use routines
which require channel numbers, the number is actually
the number of the IOCB which contains the information
about a given peripheral device. That does not mean
that certain IOCBs handle certain peripherals. You
must set up one of the IOCBs so that it will handle the
peripheral you want it to.   This is done using the
Library routine "Open", and so is not a difficult task
to accomplish.

When you see the term "default channel" it refers to
the IOCB ACTION! sets up and uses for screen display
purposes. This means that routines which do I/O using
"default channel" will get and put information from and
to the screen (device "E:").

NOTE: the default channel is channel 0.

NOTE: for more information on IOCBs, see your Operating
System reference manual.

1.2 Library Format

The library routines are presented in a manner which
makes it very easy to understand how to use and call
them. To show you what we mean, let's take one of the
routines and explain what information each part of the
presentation format can tell you. The routine we'll
look at is "Locate".

Example:

5.8 BYTE FUNC Locate
----

purpose: determine the color or character at a given
             screen location.

format: BYTE FUNC Locate(CARD col, BYTE row)

parameters: col - is a column number valid in the
                   current graphics mode.
            row - is a row number valid in the current
                   graphics mode.

description:
This routine retrieves the ATASCII code of the
character or the number of the color at the specified
location. The registers this routine uses are
incremented so as to point to the adjacent horizontal
position (the first position in the next line if you
Located the last position on a line). All of the Get,
Put, Print, and Input routines also use these registers
as references for the current cursor location, so you
can use this to move to any position and then use
another routine to manipulate what's there.

            -        -   -   -   -   -

The first thing you see is the section number and name
of the routine, including what type of routine it is
(in this case a BYTE FUNCtion). This is followed by a
short description of the purpose of the routine. The
format of the routine itself is then given in the form
of a routine declaration. The declaration form is used
instead of the form used to call that routine because
it tells you more information about the routine in
question, including:

            1) the routine's type (PROC or FUNC)
            2) all the parameters
            3) the data type of each parameter

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After the format of the routine is given the parameters
required by that routine are explained one by one. The
last piece of information is a description which
discusses the use of the routine in general and its
performance in certain special conditions.

Chapter 2: Output Routines

The ACTION! Library provides an extremely extensive
group of routines to put both numeric and string data
out to any channel.

The two basic output routines -- Print and Put -- have
options which allow you to direct the output to a
specific channel and/or output an EOL (End of Line,
a.k.a. <RETURN>) following the data. We'll go into
these options in more detail in the following sections.

2.1 The Print Procedures

The procedures we are about to discuss all have one
thing in common: they begin with the word "Print".
From this alone you can tell that they print something
out somewhere, but who knows what and where? The
answers to these questions can be found by looking at
the option(s) tagged onto the end of the word "Print".

These options all consist of a single letter, but you
can employ up to three options at one time because
different options control different aspects of the
output. "Is this ever confusing!" It might seem that
way, but let's look at the format of Print to see how
these options are grouped:

        Print<data type>{D}{E}(<parameters>)

where
        Print   is the basic function name.

        <data type>   tells what type of data you want
                        to output. The options here are:
                        B   (BYTE type data)
                        C   (CARD type data)
                        I   (INT type data)
                        <nothing> (a string)

        D   stands for "device", and is used
                        when you want to define which
                        device (channel) you want the
                        output to go to.

        E   stands for EOL (End Of Line), and
                        is used to ouput a <RETURN> after
                        the data.

        <parameters>   are the parameters required by the
                        procedure, and range in number.

NOTE: Both the 'D' and 'E' are optional, but a data type is always specified (because 'a string' is assumed to be the type of data output if no type is explicitly given).

From the above format you can see that the following are all the possible Print routines:

		strings	BYTEs	CARDs	INTs
No Options	-	Print	PrintB	PrintC	PrintI
With EOL	-	PrintE	PrintBE	PrintCE	PrintIE
To Device	-	PrintD	PrintBD	PrintCD	PrintID
Both Options	-	PrintDE	PrintBDE	PrintCDE	PrintIDE

Notice that we have grouped the procedures according to the type of data which they output. This is the way in which we group them in the following sections, with each section giving the purpose, format, parameters, and discussion for each option of the Print procedure basic to that type of data.

There is one Print procedure not in the above list because it is a very special case as far as output is concerned. Its name is PrintF, and it allows you to format output which contains numbers and strings. A separate section is devoted to this routine alone.

2.1.1 Printing Strings

There are four string printing procedures, thus making all the options discussed in the previous section available.

purpose: to print out a string, using some format options

formats: PROC Print(<string>)
            PROC PrintE(<string>)
            PROC PrintD(BYTE channel, <string>)
            PROC PrintDE(BYTE channel, <string>)

parameters: <string> - is either a string constant with double quotes or the identifier of a BYTE ARRAY (which you want printed out as a string)
            channel - is a valid channel number (0 - 7)

description:
These four procedures print out strings, thus:

        Print   outputs the string to the default channel without a <RETURN> at the end.
        PrintE   outputs the string to the default channel with a <RETURN> at the end.
        PrintD   outputs the string to a specified channel without a <RETURN> at the end.
        PrintDE outputs the string to a specified channel with a <RETURN> at the end.

Their usage is very straightforward and simple, but you must remember that, with the procedures which require a channel, the channel must first be opened.

2.1.2 Printing BYTE Numbers

The following four procedures are used to print BYTE
type data in decimal format. They start with the
'PrintB' base, and then add the possible options.

purpose: to output one byte of data as a decimal
            number.

formats: PROC PrintB(BYTE number)
            PROC PrintBE(BYTE number)
            PROC PrintBD(BYTE channel, number)
            PROC PrintBDE(BYTE channel, number)

parameters: number - is an arithmetic expression (re-
                      member that arithmetic expressions
                      can simply be a constant or variable
                      name).
            channel - is a valid channel number (0 - 7)

description:
The above procedures output BYTEs as follows:

            PrintB   outputs the byte to the default channel
                     without a <RETURN> at the end.
            PrintBE outputs the byte to the default channel
                     with a <RETURN> at the end.
            PrintBD outputs the byte to a specified channel
                     without a <RETURN> at the end.
            PrintBDE outputs the byte to a specified channel
                     with a <RETURN> at the end.

2.1.3 Printing CARD Numbers
----

purpose: to output numbers as CARDs in decimal
              format.

formats: PROC PrintC(CARD number)
              PROC PrintCE(CARD number)
              PROC PrintCD(CARD channel, number)
              PROC PrintCDE(CARD channel, number)

parameters: number - is an arithmetic expression (re-
                     member that arithmetic expressions
                     can simply be a constant or variable
                     name).
            channel - is a valid channel number (0 - 7)

description:
The above procedures output CARDs as follows:

          PrintC   outputs the CARD to the default channel
                    without a <RETURN> at the end.
          PrintCE   outputs the CARD to the default channel
                    with a <RETURN> at the end.
          PrintCD   outputs the CARD to a specified channel
                    without a <RETURN> at the end.
          PrintCDE outputs the CARD to a specified channel
                    with a <RETURN> at the end.

2.1.4 Printing INT Numbers
----

purpose: to output numbers as INTs in decimal
            format.

formats: PROC PrintI(INT number)
            PROC PrintIE(INT number)
            PROC PrintID(INT channel, number)
            PROC PrintIDE(INT channel, number)

parameters: number - is an arithmetic expression (re-
                   member that arithmetic expressions
                   can simply be a constant or variable
                   name).
            channel - is a valid channel number (0 - 7)

description:
The above procedures output INTs as follows:

            PrintI   outputs the INT to the default channel
                     without a <RETURN> at the end.
            PrintIE outputs the INT to the default channel
                     with a <RETURN> at the end.
            PrintID outputs the INT to a specified channel
                     without a <RETURN> at the end.
            PrintIDE outputs the INT to a specified channel
                     with a <RETURN> at the end.

2.1.5 PROC PrintF - Formatted Output

The PrintF procedure allows you to output numbers and strings on the same line through the use of a "format control string". This string tells the procedures exactly how you want the output to look.

purpose: formatted output of data

format: PrintF("<control string>", <data>|:, <data>:|)

arguments: <control string>- the control string is made
                            up of format controls and string
                            text.   The text is output directly,
                            and the controls (maximum of 5) give
                            information for outputting the <data>
                            parameters given.
            <data> - is an arithmetic expression, which
                            will be formatted according to its
                            format control.   The first control
                            tells how to output the first <data>,
                            the second control tells how to
                            output the second <data>, and so on.

description:
This is a sophisticated procedure enabling you to output formatted data to the default channel.   Up to five different data elements can be interspersed into a string, each with its own output format.   The format controls are as follows:

    <control>   formatted data type
    ---------   -------------------
      %S   (output data as a string)
      %I   (output data as an INT)
      %U   (output data as an Unsigned CARD)
      %C   (output data as a CHARacter)
      %H   (output data in unsigned hexadecimal)
      %%   (output the '%' character)
      %E   (output an EOL (<RETURN>))

Notice that two of the controls (%E and %%) do not manipulate or require data elements.   They are used to change the page formatting, not the data element formatting.

A maximum fo five controls are allowed, and each data element requires its own control.

Characters in the control string which are not themselves controls are output directly; that is, exactly as the are in the string.

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2.2 The Put Procedures

The "Put" group of library routines are used to output single characters (i.e., output BYTE type data as an ATASCII character). These routines use options very similar to those in "Print", and so the options need not be re-introduced here.

purpose: to output a single ATASCII character, using
             specified format options.

formats: PROC Put(CHAR character)
             PROC PutE()
             PROC PutD(BYTE channel, CHAR character)
             PROC PutDE(BYTE channel, CHAR character)

parameters: character - is an arithmetic expression
                        (remember that arithmetic expres-
                        sions can simply be a constant or
                        variable name).
            channel   - is a valid channel number(Ø - 7)

description:
These procedures output characters as follows:

        Put   outputs the character to the default
                channel without a <RETURN> at the end.
        PutE   outputs an EOL (<RETURN>) character to
                the default channel.
        PutD   outputs the character to a specified
                channel without a <RETURN> at the end.
        PutDE   outputs the character to a specified
                channel with a <RETURN> at the end.

Chapter 3: Input Routines

In this chapter we discuss the routines which
complement the Print and Put routines; that is, they
input data from somewhere. Similar to the Output
routines, the type of data that is input and where it
comes from is defined through the use of options.

'Input' and 'Get' are the input routines, and each has
its own set of options very similar to those available
in the output routines.

The Input routines are grouped into two categories:
those which input numeric data, and those which input
string data. Each will be dealt with separately.

There is only one Get routine (GetD), and it will be
discussed in the last section of this chapter.

3.1 Numeric Input

The following six functions allow you to input any type of numeric data from any channel. We have grouped them all together because they are very easy to understand and so do not require separate sections, as did the routines used to output numbers did.

purpose: to input numeric data

formats: BYTE FUNC InputB()
             BYTE FUNC InputBD(BYTE channel)
             CARD FUNC InputC()
             CARD FUNC InputCD(BYTE channel)
             INT FUNC InputI()
             INT FUNC InputID(BYTE channel)

parameters: channel - is a valid channel number (Ø - 7)

description:
The functions input data as follows:

        InputB   inputs a BYTE number from the default
                   channel.
        InputBD   inputs a BYTE number from a specified
                   channel.
        InputC   inputs a CARD number from the default
                   channel.
        InputCD   inputs a CARD number from a specified
                   channel.
        InputI   inputs an INT number from the default
                   channel.
        InputID   inputs an INT number from a specified
                   channel.

Chapter 4: File Manipulation Routines

This chapter is devoted to those routines which deal
with external devices (printer, disk drive, cassette,
etc.). With these routines you can open a channel (an
IOCB), close a channel, and do extensive disk file
manipulation.

4.1 PROC Open
----

purpose: set up an IOCB channel to allow I/O using
            a peripheral device.

format: PROC Open(BYTE channel, <filestring>, BYTE mode, aux2)

parameters: channel - is a valid channel number (0 - 7)
            <filestring> - is the string constant (or
                        array identifier of that string
                        constant) used as the device (D:,
                        P:, S:, etc.) being opened on the
                        given channel (IOCB) number. "D:"
                        files also require a filename.
            mode   - is the number designating the
                        type of I/O, thus:
                        4 - read only
                        6 - read directory
                        8 - write only
                        9 - write append
                        12 - read/write (update)
            aux2   - a device dependent value (usually
                        zero)

description:
This procedure opens a given channel the device
specified in <filestring>. The I/O mode can be set
(see 'mode' above for the number codes). Any device
dependent codes are passed through 'aux2'.

WARNING: do not Open channel 7, because it is used by
the ACTION! system to do its own screen input. You
can use channel 7 in your program for getting
characters from K:, but, since that assumes that
channel 7 is open, you need the ACTION! cartridge to
run the compiled version of the program (because
ACTION! opens channel 7 to K:).

3.2 String Input

String inputting is accomplished by suffixing the
"Input" base with the character "S". The are three
such procedures in the ACTION! Library, and they allow
you to input a string from any channel and/or define
the maximum length of the input string.

purpose: to input string data

formats: PROC InputS(<string>)
             PROC InputSD(BYTE channel, <string>)
             PROC InputMD(BYTE channel, <string>, BYTE max))

parameters: <string> - is the identifier of a BYTE
                       ARRAY.
            channel - is a valid channel number (0 - 7)
            max   - is the maximum length allowable
                       for the input string. The string
                       is truncated to 'max' length if it
                       is too long.
description:
Here is an outline of what each procedure does:

        InputS   inputs a string of up to 255 char-
                    acters from the default channel.
        InputSD   inputs a string of up to 255 char-
                    acters from a specified channel.
        InputMD   inputs a string of up to 'max' char-
                    acters from a specified channel.

3.3 CHAR FUNC GetD
----

purpose: to input a single character from a given
             channel.

format: CHAR FUNC GetD(BYTE channel)

parameters: channel - is a valid channel number (0 - 7)

description:
This function is used to get one character from the
device specified by 'channel'. The character is
returned through the function as its ATASCII character
set number.

4.4 PROC Note
----

purpose: to return the current file sector and byte
               offset within that sector on a specified
               disk drive.

format: PROC Note(BYTE chan, CARD POINTER sector,
                         BYTE POINTER offset)

parameters: chan   - is a valid channel number (Ø - 7)
            sector - is a pointer to the sector number
                      variable.
            offset - is a pointer to the byte offset
                      variable.

description:
This procedure returns the disk sector and byte offset
within that sector of the next byte to be read or
written (i.e., it returns the value of the disk file
pointer).

4.5 PROC Point
----

purpose: to set the disk file pointer (sector and
               byte offset) to allow random file access.

format: PROC Point(BYTE chan,CARD sector,BYTE offset)

parameters: chan   - is a valid channel number (Ø - 7)
            sector - is a valid sector number (1 - 72Ø)
            offset - is the byte offset within that
                      sector.

description:
This procedure allows you to set the disk file pointer
to any location within a disk file, thus enabling
random access of information.

NOTE: the disk file must have been Opened mode 12
(update) for the Point routine to work.

4.2 PROC Close

purpose: to close an IOCB channel to a device

format: PROC Close(BYTE channel)

parameters: channel - is a valid channel number (0 - 7)

description:
This procedure closes the specified channel. At the
end of a program you should always close any devices
you've opened in the course of that program.

NOTE: DO NOT Close channel 7, as ACTION! uses it.

4.3 PROC XIO

purpose:

format: PROC XIO(BYTE chan,0,cmd,aux1,aux2,<filestring>)

parameters: chan - is a valid channel number (0 - 7)
            cmd - is the equivalent of the IOCB
                 COMMAND byte (ICCOM in OS/A+ and DOS
                 XL)
            aux1 - is the first auxilliary byte in the
                 IOCB (ICAUX1 in OS/A+ and DOS XL)
            aux2 - is the second auxilliary byte in the
                 IOCB (ICAUX2 in OS/A+ and DOS XL)
            <filestring> - is a character string spec-
                 ifying a standard device (with a file
                 name in the case of "D:").

description:
This procedure is a system call designed to provide
access to DOS. Those of you familiar with Atari BASIC,
BASIC A+, or BASIC XL will recognize XIO as a direct
translation of BASIC's XIO statement.

Rather than give a complete list of all the possible
uses of XIO here, we will refer you to Chapter 8 of
either the OS/A+ or DOS XL manual.   The ACTION!   XIO
procedure can perform all the system commands listed
therein other than NOTE, POINT, and the various data
transfer operations -- all of which are available via
other ACTION! Library routines.

NOTE: the "0" given as the second parameter is
required.

5.2 PROC SetColor
----

purpose: sets the specified color register to the
             color given by 'hue' and 'luminance'.

format: PROC SetColor(BYTE register,hue,luminance)

parameters: register - is one of the five   color
                         registers (Ø - 4)
            hue   - is the hue of the color.
            luminance - is the luminance of the color.

description:
This routine allows you to set the color of a specific
color register, and so manipulate the colors displayed
in a given mode.   The following tables give some
information pertinent to the usage of this procedure.

SetColor hue num.	Color	SetColor hue num.	Color
Ø	Gray	8	Blue
1	Gold	9	Light Blue
2	Orange	1Ø	Turquoise
3	Red-Orange	11	Green-Blue
4	Pink	12	Green
5	Purple	13	Yellow-Green
6	Purple-Blue	14	Orange-Green
7	Blue	15	Light Orange

The above table shows the 16 hues available on the
ATARI, and their numeric code for use as the 'hue'
parameter of the SetColor procedure.

Register	Default Color	Default Luminance	Color
Ø	2	8	Orange
1	12	1Ø	Green
2	9	4	Dark Blue
3	4	6	Pink or Red
4	Ø	Ø	Black

This table shows which colors are the defaults used
when you don't specify your own color for a given
SetColor 'register'.

NOTE: Colors may vary depending upon the television or
monitor type, condition, and adjustment.

The luminance value (a measure of the "brightness" of a
color) ranges between Ø and 15, where Ø is darkest and
15 is brightest.

Chapter 5: Graphics and Game Controllers

The ACTION! Library contains quite a few routines
designed specifically to make game writing (using
visual and sound effects) easy and quick. At your
fingertips you have the ability to manipulate bit-map
graphics (i.e., the BASIC graphics modes), the myriad
of sounds available on the ATARI, and get information
about the game controllers (both paddle and joystick).

Since the description of each routine best illustrates
its usage, we'll jump right into the routines
themselves without further discussion.

5.1 PROC Graphics
----

purpose: to enable bit-map ATARI graphics.

format: PROC Graphics(BYTE mode)

parameters: mode - is the number of the graphics mode,
                    as in the BASIC 'Graphics' routine
                    (see table below).

description:
This procedure is exactly equivalent to the BASIC
command of the same name, and allows you access to the
many varied graphics modes available on the ATARI.

The following table gives some information about the 9
base graphics modes. These modes are all split screen;
to get full screen, add 16 to the base mode number; to
preserve the current screen as you change modes, add 32
to the base mode number; to get both of these options,
add 48 to the base mode number.

Gr. Mode	Mode Type	Rows	(split) Cols	(full) Cols	Num of Colors
Ø	TEXT	40	N/A	24	2
1	TEXT	20	20	24	5
2	TEXT	20	10	12	5
3	GRAPHICS	40	20	24	4
4	GRAPHICS	80	40	48	2
5	GRAPHICS	80	40	48	4
6	GRAPHICS	160	80	96	2
7	GRAPHICS	160	80	96	4
8	GRAPHICS	320	160	192	1/2

5.4 PROC Plot
----

purpose: to position the cursor at a specified
                location, and then display a color using
                the library variable 'Color'.

format: PROC Plot(CARD col,BYTE row)

parameters: col - is the horizontal column number of
                  the point being plotted.
            row - is the vertical row number of the
                  point being plotted.

description:
This procedure is used in graphics modes 3 - 8 to plot
a point on the screen. The size of the point displayed
depends on the graphics mode, and the color of the
point depends on the current value of the library
variable 'Color' (see previous section).

5.5 PROC DrawTo
----

purpose: (must be preceeded by a 'Plot') to draw a
                line between the point just Plotted and the
                specified position.

format: PROC DrawTo(CARD col,BYTE row)

parameters: col - is the horizontal column number of
                  the end point of the line.
            row - is the vertical row number of the
                  end point of the line.

description:
This procedure is used in graphics modes 3 - 8 to draw
a line from the point just plotted (using 'Plot') and
the position given by the parameters. The color of the
line depends on the current value of the library
variable 'Color' (see section 5.3).

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5.3 BYTE color

'color' isn't a library routine, but a variable defined
in the library for use with the 'Plot', 'DrawTo', and
'Fill' library procedures. After you pick your
graphics mode (using 'Graphics') and set up the color
registers (using 'SetColor'), you can plot and draw in
that mode using any of the colors you've specified by
first using the assignment:

                        color=<number>

where <number> is related to the color register
containing the color you want to use. The following
table shows this relationship for the different
graphics modes. For every group of related modes, each
SetColor 'register' is followed by its associated
'color' <number>, and some descriptive comments.

Graphics Mode	SetColor 'register'	Color number	Description and Comments
Ø and all text windows	Ø	N/A	--
	1	N/A	--
	2	N/A	Character luminance
	3	N/A	Background
	4	N/A	Border
1,2	Ø	N/A	Character
	1	N/A	Character
	2	N/A	Character
	3	N/A	Character
	4	N/A	Background,Border
3,5,7	Ø	1	Graphics Point
	1	2	Graphics Point
	2	3	Graphics Point
	3	--	--
	4	Ø	Gr. Pt.,Border,Background
4,6	Ø	1	Graphics Point
	1	--	--
	2	--	--
	3	--	--
	4	Ø	Gr. Pt.,Border,Background
8	Ø	--	--
	1	1	Graphics Point luminance
	2	Ø	Graphics Point,Background
	3	--	--
	4	--	Border

5.8 BYTE FUNC Locate
----

purpose: determine the color or character at a given
             screen location.

format: BYTE FUNC Locate(CARD col, BYTE row)

parameters: col - is a column number valid in the
                   current graphics mode.
            row - is a row number valid in the current
                   graphics mode.

description:
This routine retrieves the ATASCII code of the
character or the number of the color at the specified
location. The registers this routine uses are
incremented so as to point to the adjacent horizontal
position (the first position in the next line if you
Located the last position on a line). All of the Get,
Put, Print, and Input routines also use these registers
as references for the current cursor location, so you
can use this to move to any position and then use
another routine to manipulate what's there.

5.6 PROC Fill
----

purpose: (must be preceeded by a 'Plot') fills a box
              with a color.

format: PROC Fill(CARD col,BYTE row)

parameters: col - is the horizontal column number of
                   the lower right corner of the box being
                   filled.
            row - is the vertical row number of the
                   lower right corner of the box being
                   filled.

description:
This allows you to make boxes of color in graphics
modes 3 - 8. The upper left corner of the box is
defined by the position of the 'Plot' immediately
before the 'Fill', and the lower right corner is given
by the parameters. The color used is decided by the
contents of the library variable 'Color'.

5.7 PROC Position
----

purpose: to position the cursor anywhere on the
              screen

format: PROC Position(CARD col,BYTE row)

parameters: col - is the horizontal column number of
                   the position desired.
            row - is the vertical row number of the
                   position desired.

description:
This precedure sets the cursor location to the
specified position in any graphics mode. The library
routines Print, Put, Input, and Get use the cursor
registers this command sets when doing their respective
functions.

5.10 SndRst

purpose: to reset all the sound voices.

format: PROC SndRst()

parameters: none

description:
This procedure resets all the sound voices to produce
no sound.

5.11 BYTE FUNC Paddle

purpose: to return the current numeric value
             (position) of one of the paddles.

format: BYTE FUNC Paddle(BYTE port)

parameters: port - is the port number (0 - 7) of the
             desired paddle.

description:
This function returns the current value of the
specified paddle port.

5.12 BYTE FUNC PTrig

purpose: to determine whether a paddle trigger has
             been pressed.

format: BYTE FUNC PTrig(BYTE port)

parameters: port - is the port number (0 - 7) of the
             desired paddle.

description:
This function returns the current value of the given
paddle's trigger. A value of 0 is returned if the
trigger is pressed, otherwise the value returned is
non-zero.

5.9 PROC Sound

purpose: to enable the sound capabilities of the
            ATARI.

format: PROC Sound(BYTE voice,pitch,distortion,volume)

parameters: voice - is one of the four voices
                     available on the ATARI (Ø - 3).
            pitch - is the frequency of the sound.
                     The lower the number, the higher the
                     pitch.
            distortion - is a measure of the sound's
                     "fuzziness" (Ø - 14, even values).
            volume - is the volume of the sound(Ø - 16)

description:
This procedure allows you to control the
sound-generating apparatus on the ATARI, much like the
BASIC command of the same name. Distortion values 1Ø
is the only one useful for making music. The others
are useful for airplane, racecar, etc. sound effects.

Here is a table for various musical notes using
distortion 1Ø.

	'pitch'	Note(s)		'pitch'	Note(s)
HIGH	29	C		91	F
NOTES	31	B		96	E
	33	A# or Bb		1Ø2	D# or Eb
	35	A		1Ø8	D
	37	G# or Ab		114	C# or Db
	4Ø	G	MIDDLE C	121	C
	42	F# or Gb		128	B
	45	F		136	A# or Bb
	47	E		144	A
	5Ø	D# or Eb		153	G# or Ab
	53	D		162	G
	57	C# or Db		173	F# or Gb
	6Ø	C		182	F
	64	B	LOW	193	E
	68	A# or Bb	NOTES	2Ø4	D# or Eb
	72	A		217	D
	76	G# or Ab		23Ø	C# or Db
	81	G		243	C
	85	F# or Gb			

Chapter 6: String Handling / Conversion

The routines discussed in this chapter allow you to
manipulate strings, change a number to a string, and
change a string into a number. No further discussion
is necessary, since the routine descriptions speak for
themselves.

6.1 String Handling Routines

The following four routines make possible some advanced
string manipulation, including string comparison,
string copying, and substring insertion. There is one
caution, however, and that is: remember that the
maximum length of a string is 255 characters, so don't
try to use these routines to create or to manipulate
big CHARacter arrays.

6.1.1 INT FUNC SCompare
----

purpose: to compare alphabetically two strings.

format: INT FUNC SCompare(<string1>,<string2>)

parameters: <string1> - is a string with double quotes,
                        or the identifier of a CHAR ARRAY
                        which is a string.
            <string2> - is a string with double quotes,
                        or the identifier of a CHAR ARRAY
                        which is a string.

description:
This function returns a value dependent on the
following table:

                comparison   value returned
                ----------   --------------
         <string1> < <string2>   value < 0
         <string1> = <string2>   value = 0
         <string1> > <string2>   value > 0

The comparison is alphabetic, so this is a good way to
alphabetize a list of strings.

5.13 BYTE FUNC Stick
----

purpose: to return the current numeric value of a
            specified joystick.

format: BYTE FUNC Stick(BYTE port)

parameters: port - is the port number (Ø - 3) of the
            desired joystick.

description:
This function returns the current position of the
joystick, using codes as in the following diagram.

```
                  14
          1Ø      |      6
            \     |    /
             \    |   /
  11 ------  15------ 7
             /   |  \
            /    |   \
          9      |      5
                 13
```
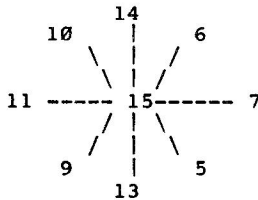
5.14 BYTE FUNC STrig
----

purpose: to determine whether a joystick trigger has
            been pressed.

format: BYTE FUNC STrig(BYTE port)

parameters: port - is the port number (Ø - 3) of the
            desired joystick.

description:
This function returns the current value of the given
joystick's trigger. A value of Ø is returned if the
trigger is pressed, otherwise the value returned is
non-zero.

6.1.4 PROC SAssign

purpose: to copy one string into part of another string.

format: PROC SAssign(<dest>,<source>, BYTE start,stop)

parameters: <dest>   - is the identifier of the destination string (CHAR ARRAY) for the string copy.

<source> - is the string with double quotes or identifier of the CHAR ARRAY used as the source string for the copy.

start   - is the starting point in <dest> for the copy.

stop   - is the stopping point in <dest> for the copy. If 'stop' is greater than the length of <dest>, then the length of <dest> is changed to 'stop'.

description:
This procedure is used to copy one string (<source>) into part of another (<dest>). <source> will be copied starting at element 'start' of <dest>, and the copying will stop at element 'stop' of <dest>. If the space allowed (stop-start+1) in <dest> is greater than the length of <source>, then 'stop' will be changed to make the space available and the length equal.

The copying this procedure does will overwrite the old elements of <dest> as it puts in <source>.

6.1.2 PROC SCopy

purpose: to copy one string into another.

format: PROC SCopy(<dest>,<source>)

parameters: <dest>   - is the identifier of the
                       destination string (CHAR ARRAY)
                       for the string copy.
            <source> - is the string with double quotes
                       or identifier of the CHAR ARRAY
                       used as the source string for the
                       copy.

description:
This procedure copies the contents of <source> into
<dest>. If <dest> is dimensioned to be shorter than
the length of <source>, then only the part of <source>
which fits into <dest> will be copied. If <dest> is
longer than <source>, then SCopy will copy all of
<source> into <dest>, but not alter the rest of <dest>.

HINT: don't dimension <dest> to avoid all the above
problems.

6.1.3 PROC SCopyS

purpose: to copy part of a string into another
             string.

format: PROC SCopyS(<dest>,<source>, BYTE start,stop)

parameters: <dest>   - is the identifier of the
                       destination string (CHAR ARRAY)
                       for the string copy.
            <source> - is the string with double quotes
                       or identifier of the CHAR ARRAY
                       used as the source string for the
                       copy.
            start   - is the starting point in
                       <source> for the copy.
            stop   - is the stopping point in
                       <source> for the copy. If 'stop'
                       is greater than the length of
                       <source>, it is changed to equal
                       the length of <source>.

description:
This procedure will copy the elements of <source> from
element 'start' to element 'stop' into <dest>. In
essence, this works just like SCopy, but copies only a
part of <source> instead of the whole thing.

Chapter 7: Miscellaneous Routines

This chapter contains those routines which don't really
fit into any category, but are useful nonetheless. The
routines themselves are:

Rand	-	a random number generator
Break	-	a routine useful when debugging
Error	-	a system routine you can replace
Peek	-	view a byte of memory
PeekC	-	view two bytes of memory (as a CARD)
Poke	-	put a BYTE value into memory
PokeC	-	put a CARD value into memory
Zero	-	zero out a section of memory
SetBlock	-	fill a block of memory with a value
MoveBlock	-	move a block of memory
Device	-	the "default device" variable
Trace	-	controls the 'TRACE' compile option
List	-	controls the 'LIST' compile option
EOF	-	contains EOF status for all channels

As you can see, the tasks these routines perform are
quite diverse; hence their own chapter.

7.1 BYTE FUNC Rand
----

purpose: to generate a random number.

format: BYTE FUNC Rand(BYTE range)

parameters: range - is the upper limit for the random
                     number.

description:
This function will return a random number between 0 and
('range'-1). If 'range' is 0, then a random number
between 0 and 255 is returned.

6.2 Number to String Conversions

The following three procedures convert the number given
as a parameter into a character string. There is one
procedure for each of the numeric data types.

purpose: to change a number into a character string.

format: PROC StrB(BYTE number,<string>)
            PROC StrC(CARD number,<string>)
            PROC StrI(INT number,<string>)

parameters: number   - is an arithmetic expression (re-
                       member that arithmetic expressions
                       can simply be a constant or
                       variable name).
            <string> - is the identifier of a CHAR
                       ARRAY.

description:
These procedures turn BYTE, CARD, or INT values into
character strings composed of the digits of the given
number.

6.3 String to Number Conversions
----

purpose: to convert a string composed of digits into
            a number.

format: BYTE FUNC ValB(<string>)
            CARD FUNC ValC(<string>)
            INT FUNC ValI(<string>)

parameters: <source> - is a string with double quotes
                       or identifier of a CHAR ARRAY,
                       composed of digits ("Ø" - "9")
                       only.

description:
These functions will return the numeric value (BYTE,
CARD, or INT, depending on the function used) of the
given string.

system error routine so that it points to your error
routine instead. You don't have to call this routine
because it will be called by the ACTION! system when an
error is encountered.

Notice that we saved the original error routine
pointer, and then, at the end of the program, we reset
that pointer (which was changed to point to your error
routine) back to the system error routine. This was
done so that the system could again use its error
routine after your program finished running.

WARNING: the capability of substituting your error
routine for the system's should be used very carefully,
because you might to forget to check for something in
you routine, and thereby cause the entire system to
crash.

7.4 BYTE FUNC Peek and CARD FUNC PeekC
----

purpose: to return the value (BYTE or CARD) at a
            given memory location.

format: BYTE FUNC Peek(CARD address)
            CARD FUNC PeekC(CARD address)

parameters: address -. is the address of the memory lo-
            cation you desire to look at.

description:
These two functions allow you to look at memory during
program execution, either as a BYTE or a CARD in LSB,
MSB order.

7.2 PROC Break
----

purpose: to stop program execution.

format: PROC Break()

parameters: none

description:
This procedure allows you to stop your program's
execution to examine variables and do other debugging.
You can continue program execution starting with the
statement following the 'Break' routine call by using
the 'PROCEED' monitor command.

7.3 PROC Error

This is the procedure the ACTION! system itself calls
when it (or CIO) encounters an error. If you want to
trap your own errors, you could write a routine to do
this, and then make ACTION! use your error routine
instead of its own simply by having the following
statements in your program:

```
PROC MyError(BYTE errcode)
;**** this is your error routine, and the error
;code number is passed to it by the ACTION! system.

; your error handling routines go here

RETURN ;end of PROC MyError

PROC main() ;your main procedure

   CARD temperr      ;holds the address of the system's
                     ;error routine (PROC Error).

   temperr=Error ;save the address of the system error
                 ;routine
   Error=MyError ;make the address of the system error
                 ;routine point to the start of your
                 ;error routine.

   ;the body of your program goes here.

   Error=temperr ; reset the address of the system error
                 ;routine back to the real system error
                 ;routine, not yours.
RETURN ;end of program.
```

All you are really doing is changing the pointer to the

7.7 PROC SetBlock
----

purpose: to set the memory locations of a memory
            block to a specified value.

format: SetBlock(BYTE POINTER address, CARD size, BYTE value)

parameters: address - is a pointer to the starting
                      address of the block you want
                      to set.
            size   - is the size of the block you want
                      to set.
            value   - is the value you want the bytes
                      in the block set to.

description:
With this procedure you can set all the values of the
memory locations in a block to 'value'. This block
starts at 'address' and ends at location
'address'+'size'-1.

7.8 PROC MoveBlock
----

purpose: to move the contents of a block of memory.

format: PROC MoveBlock(BYTE POINTER dest,source, CARD size)

parameters: dest   - is a pointer to the start of the
                      destination memroy block.
            source - is a pointer to the start of the
                      source memory block.
            size   - is the size of the block you want
                      to move.

description:
This procedure moves the values in a block starting at
address 'source' and ending at address
'source'+'size'-1 to a block starting at address 'dest'
and ending at address 'dest'+'size'-1. If 'dest' is
greater than 'source', and there is not 'size' space
between them, then the move will not work properly
because part of the 'source' you are trying to move is
in the 'dest' space.

7.5 PROC Poke and PROC PokeC
----

purpose: to insert new values (BYTE or CARD) into a
             specified memory location.

format: PROC Poke(CARD address, BYTE value)
             PROC PokeC(CARD address, value)

parameters: address - is the address of the memory lo-
                       cation you desire to change.
             value   - is the value you want put into
                       the memory location specified by
                       'address'.   When using PokeC, the
                       CARD value is stored in 'address'
                       and 'address'+1 in LSB, MSB order.
description:
These procedures allow you to change the contents of
memory during program execution by changing the given
address to the specified value.

7.6 PROC Zero
----

purpose: to zero out a block of memory.

format: PROC Zero(BYTE POINTER address, CARD size)

parameters: address - is a pointer to the starting
                       address of the block you want
                       zeroed.
             size   - is the size of the block you want
                       zeroed.

description:
With this procedure you can set all the values of the
memory locations in a block to Ø. This block starts at
'address' and ends at location 'address'+'size'-1.

7.12 BYTE ARRAY EOF(8)

With this library variable you can found out if you've reached the End Of File on any channel. Simply give the number of the channel as the subscript to the EOF array. For example, if you wanted to find out if you have reached the End of File on channel 1 (the channel must be open), then you would use:

```
IF EOF(1) THEN
    :
    :
```

EOF equals 1 when the End Of File has been reached, otherwise it is 0.

7.9 BYTE device

'device' is a variable defined in the ACTION! Library,
and allows you to control the 'default channel'
(device) for I/O. The number contained by 'device' is
the channel number of the default device, so, for
example, you send default output to the printer using
the following statements:

```
Close(5)     ;avoid a 'File already Opened' error
Open(5,"P:",8)
device=5
```

and then reset it to the screen (when you want to)
using the following statements:

```
Close(5)     ;close "P:"
device=0
```

7.10 BYTE TRACE

This library variable allows you to control the 'TRACE'
compiler option from within your program. You must use
it with the 'SET' compiler directive, and it must come
at the beginning of your program. Setting 'TRACE' to 0
turns off the option, and setting it to 1 turns it on.

Example:
```
      SET TRACE=0
```

7.11 BYTE LIST

This library variable controls the 'LIST' compiler. As
with 'TRACE' above, this variable must be used in a
'SET' directive, and it must come at the beginning of
your program. A 0 turns the listing off, and a 1 turns
it on.

Appendix A: ACTION! Language Syntax

The following is the syntax of the ACTION!   language in
Backus-Naur   form.   This   form has a couple of special
characters:

        Symbol   Meaning
        ------   -------
        ::=   "is defined as"
        | "or"
        {}   "optional"

The appendix is set up to allow you easy access to the
particular information you want, with   subsections   as
follows:

Fundamental Data Types

<fund type> ::= CARD | CHAR | BYTE | INT

A.3 ACTION! Program Structure

ACTION! Program

<program> ::= <program> MODULE <prog module> |
              {MODULE} <prog module>
<prog module> ::= {<system decls>} <routine list>

A.4 Declarations

System Declarations

<system decls> ::= <DEFINE decl> | <TYPE decl> |
                        <var decl>

DEFINE Directive

<DEFINE decl> ::= <DEFINE> <def list>
<def list> ::= <def list>,<def> | <def>
<def> ::= <identifier>=<str const>

TYPE Declaration (for records)

<TYPE decl> ::= TYPE <rec ident list>
<rec ident list> ::= <rec ident list> <rec ident> |
                        <rec ident>
<rec ident> ::= <rec name>=[<field init>]
<rec name> ::= <identifier>
<field init> ::= <fund var decl>

Variable Declarations

<var decl> ::= <var decl> <base var decl> | <base var decl>
<base var decl> ::= <fund decl> | <POINTER decl> |
                        <ARRAY decl> | <record decl>

Variable Declaration for Fundamental Data Types

<fund decl> ::= <fund decl> <base fund decl> |
                    <base fund decl>
<base fund decl> ::= <fund type> <fund ident list>
<fund type> ::= CARD | CHAR | BYTE | INT
<fund ident list> ::= <fund ident list>,<fund ident> |
                            <fund ident>
<fund ident> ::= <identifier>[=<init opts>]

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A.1 ACTION! Constants

Numeric Constant

```
<num const> ::= <dec num> | <hex num> | <char>
<dec num> ::= <dec num><digit> | <digit>
<hex num> ::= <hexnum><hex digit> | $<hex digit>
<char> ::= '<any printable character>
<hex digit> ::= <digit> | A | B | C | D | E | F
<digit> ::= Ø | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```

String Constant

```
<str const> ::= "<string>"
<string> :: = <string><str char> | <str char>
<str char> ::= <all printable characters, except " >
```

Compiler Constant

```
<comp const> ::= <comp const>+<base comp const> |
                 <base comp const>
<base comp const> ::= <identifier> | <num const> |
                      <ptr ref> | *
```

A.2 Operators and Fundamental Data Types

Operators

```
<special op> ::= AND | OR | & | %
<rel op> ::= XOR | ! | = | # | <> | < | <= | > | >=
<add op> ::= + | -
<mult op> ::= * | / | MOD | LSH | RSH
<unary op> ::= @ | -
```

Procedure Structure
```
-------------------
<proc routine> ::= <PROC decl> {<system decls>}
                   {<stmt list>}{RETURN}
<PROC decl> ::= PROC <identifier>{=<addr>}({<param decl>})
<addr> ::= <comp const>
```

Function Structure
```
-------------------
<func routine> ::= <FUNC decl> {<system decls>}
                   {<stmt list>}{RETURN {<arith exp>}}
<FUNC decl> ::= <fund type> FUNC <identifier>{=<addr>}
                   ({<param decl>})
<addr> ::= <comp const>
```

Routine calls
```
-------------
<routine call> ::= <FUNC call> | <PROC call>
<FUNC call> ::= <identifier>({<params>})
<PROC call> ::= <identifier>({<params>})
```

Parameters
```
----------
<param decl> ::= <var decl>  NOTE:  max. of 8 parameters allowed
```

A.7 Statements
```
---------------
<stmt list> ::= <stmt list> <stmt> | <stmt>
<stmt> ::= <simp stmt> | <struc stmt> | <code block>

<simp stmt> ::= <assign stmt> | <EXIT stmt> | <routine call>
<struc stmt> ::= <IF stmt> | <DO loop> | <WHILE loop> |
                 <FOR loop>
```

Assignment Statement
```
---------------------
<assign stmt> ::= <mem contents>=<arith exp>
```

EXIT Statement
```
---------------
<EXIT stmt> ::= EXIT
```

IF Statement
```
------------
<IF stmt> ::= IF <cond exp> THEN {stmt list}
              {|:ELSEIF exten:|}{ELSE exten} FI
<ELSEIF exten> ::= ELSEIF <cond exp> THEN {stmt list}
<ELSE exten> ::= ELSE {stmt list}
```

DO - OD Loop
```
-------------
<DO loop> ::= DO {<stmt list>} {<UNTIL stmt>} OD
```

```
<init opts> ::= <addr> | [<value>]
<addr> ::= <comp const>
<value> ::= <num const>
```

Variable Declaration for Pointers
```
<POINTER decl> ::= <ptr type> POINTER <ptr ident list>
<ptr type> ::= <fund type> | <rec name>
<ptr ident list> ::= <ptr ident list>,<ptr ident> |
                     <ptr ident>
<ptr ident> ::= <identifier>{=<value>}
```

Variable Declaration for Arrays
```
<ARRAY decl> ::= <fund type> ARRAY <arr ident list>
<arr ident list> ::= <arr ident list>,<arr ident> |
                     <arr ident>
<arr ident> ::= <identifier>{(<dim>)}{=<arr init opts>}
<dim> ::= <num const>
<arr init opts> ::= <addr> | [<value>] | <str const>
<addr> ::= <comp const>
<value list> ::= <value list><value> | <value>
<value> ::= <comp const>
```

Variable Declaration for Records
```
<record decl> ::= <identifier> <rec ident list>
<rec ident list> ::= <rec ident list>,<rec ident> |
                     <rec ident>
<rec ident> ::= <identifier>{=<address>}
<address> ::= <comp const>
```

A.5 Variable References

Memory References
```
<mem reference> ::= <mem contents> | @<identifier>
<mem contents> ::= <fund ref> | <arr ref> | <ptr ref> |
                   <rec ref>
<fund ref> ::= <identifier>
<arr ref> ::= <identifier>(<arith exp>)
<ptr ref> ::= <identifier>^
<rec ref> ::= <identifier>.<identifier>
```

A.6 ACTION! Routines

Routines
```
<routine list> ::= <routine list> <routine> | <routine>
<routine> ::= <proc routine> | <func routine>
```

Appendix B: ACTION! Memory Map

```
$00   +-------------------------------+
      |      O.S. and ACTION!         |
      |         Variables             |
$CA   |-------------------------------|
      |         Free Space            |
$CE   |-------------------------------|
      |      ACTION! Variables        |
$D4   |-------------------------------|
      |     Atari Floating Point      |
      |         Registers             |
$100  |-------------------------------|
      |       Operating System        |
$480  |-------------------------------|
      |      ACTION! Variables        |
$580  |-------------------------------|
      |     Atari Floating Point      |
      |          Buffer               |
$600  |-------------------------------|
      |       Operating System        |
MEMLO |-------------------------------|
      |   ACTION! Compiler Stacks     |
LO+$200 |-----------------------------|
      |     ACTION! Editor Line       |
      |         Buffer                |
LO+$300 |-----------------------------|
      |      ACTION! Hash Tables      |
LO+$750 |-----------------------------|
      |     ACTION! Editor Text       |
      |         Buffer                |
      |- - - - - - - - - - - - - - - -|
      |    ACTION! Compiler Code      |
      |          Space                |
TOP-$800 |----------------------------|
      |   ACTION! Compiler Symbol     |
      |          Table                |
MEMTOP |------------------------------|
      |        Screen Memory          |
$A000 |-------------------------------|
      |      ACTION! Cartridge        |
$C000 |-------------------------------|
      |      O.S., ROMs, etc.         |
$FFFF +-------------------------------+
```

NOTE: the Compiler Code Space starts wherever the Editor Text Buffer ends. This makes both the Editor Buffer and the Compiler Buffer dynamic in memory. For more information on this, see part V, chapter 2.

UNTIL Statement

<UNTIL stmt> ::= UNTIL <cond exp>

WHILE Loop

<WHILE loop> ::= WHILE <cond exp> <DO loop>

FOR Loop

<FOR loop> ::= FOR <identifier>=<start> TO <finish>
                   [STEP <inc>]<DO loop>
<start> ::= <arith exp>
<finish> ::= <arith exp>
<inc> ::= <arith exp>

Code Blocks

<code block> ::= [<comp const list>]
<comp const list> ::= <comp const list> <comp const> |
                      <comp const>

A.8 Expressions

Relational Expressions

<complex rel> ::== <complex rel><special op><simp rel exp> |
                   <simp rel exp><special op><simp rel exp>
<simple rel exp> ::= <arith exp><rel op><arith exp>

Arithmetic Expressions

<arith exp> ::= <arith exp><add op><mult exp> |
                <mult exp>
<mult exp> ::= <mult exp><mult op><value> | <value>
<value> ::= <num const> | <mem reference> | (<arith exp>)

Error Code	Explanation
12	Missing THEN
13	Missing FI
14	Out of code space. See Part V, section 4.4, for more information.
15	Missing DO
16	Missing TO
17	Bad Expression. You have used an illegal expression format.
18	Unmatched parentheses.
19	Missing OD
20	Can't allocate memory. You have impared the ACTION! system, and it is unable to allocate any more memory.
21	Illegal array reference
22	The input file is too large. You need to break it into smaller pieces.
23	Illegal Conditional Expression
24	Illegal FOR statement syntax
25	Illegal EXIT. There is no DO - OD loop for the EXIT to exit out of.
26	Nesting too deep (16 levels maximum).
27	Illegal TYPE syntax.
28	Illegal RETURN.
61	Out of Symbol Table space. See Part IV for more information.
128	<BREAK> key was used to stop program execution.

Appendix C: Error Code Explanation

In this appendix we'll describe the meaning of each of
the error numbers you could encounter while programming
in ACTION!. Included are those errors which the
ACTION! system itself discovers, but not those which
the operating system discovers (errors 128 - 255).

Error Code	Explanation
0	Out of system memory. See Part II, section 4.3, and Part V, section 4.4, to find out how to remedy this error.
1	Missing " (double quote) in a string.
2	Nested DEFINEs. You can not nest the DEFINE directive.
3	Global variable symbol table full.
4	Local variable symbol table full.
5	SET directive syntax error.
6	Declaration error. You used the wrong declaration format when declaring something.
7	Invalid argument list. You gave a statement or routine too many arguments.
8	Variable not declared. Remember, you must declare your variables before you use them.
9	Not a constant. You used a variable where a constant of some kind was required.
10	Illegal assignment. You are trying to do some sort of assignment that is not allowed (e.g., var=5>7 is illegal).
11	Unknown error. You have somehow impared the ACTION! system error routines, so it can't tell you which error you have made.

Appendix E: Editor Commands Summary

E.1 I/O Commands

          Read a File   position cursor, <CTRL><SHIFT> R,
                           enter filespec
          Disk Directory   <CTRL><SHIFT> R ?n:*.* (n = device num)
          Write a File   <CTRL><SHIFT> W, enter filespec
          List to Printer <CTRL><SHIFT> W, enter P:

E.2 Cursor Movement within Window

          Up   <CTRL><up arrow>
          Down   <CTRL><down arrow>
          Right   <CTRL><right arrow>
          Left   <CTRL><left arrow>
          Start of Line   <CTRL><SHIFT> <
          End of Line   <CTRL><SHIFT> >
          Next Line   <RETURN>
          Tab   <TAB>

E.3 Tab Handling

          Set Tab   <SHIFT><SET TAB>
          Clear Tab   <CTRL><CLR TAB>

E.4 Window Movement

          Start of File   <CTRL><SHIFT> H
          Up one Screen   <CTRL><SHIFT> <up arrow>
          Down one Screen <CTRL><SHIFT> <down arrow>
          Left 1 Char.   <CTRL><SHIFT>]
          Right 1 Char.   <CTRL><SHIFT> [

E.5 Text Entry

          Enter Program   enter text
          Next Line   <RETURN>
          Control Chars.   precede each character with <ESC>

E.6 Delete Text

          Back 1 Char.   <BACK S>
          Cursor   <CTRL><DELETE>
          Delete Line   position cursor on line,
                           <SHIFT><DELETE>

Appendix D: Bibiography and References

D.1 Atari 400/800 Hardware Systems

Atari Publications:

     ATARI Personal Computer System Operating System
     User's Manual and Hardware Manual

     ATARI 810 Disk Drice Operator's Manual

     ATARI 400/800 Disk Utility

     ATARI 400/800 Operating Systems

     ATARI 400/800 Disk Operating Systems II   Reference
     Manual

Other Atari References:

     Poole, McNiff, Cook.   Your Atari Computer

D.2 Optimized Systems Software References

     OSS OS/A+ reference manual

     OSS DOS XL reference manual

Appendix F: Summary of ACTION! Monitor Commands

B   restart ACTION! system

C {"<filespec>"}   compile an ACTION! program

D   call DOS

E   go to the ACTION! Editor

O   go to the ACTION! Options Menu

P   proceed from program halt

R {"<filespec>"}   run an ACTION! program

SET <address> = <value>
                            sets a value in a specified
                            memory location

W {"<filespec>"}   save a compiled program to disk

X <statement>|:, <statement>:|
                            execute ACTION! language state-
                            ment(s)

? <address>   display value of an address (or
                            compiler constant)

* <address>   display values of all addresses,
                            starting   at   an   address (or
                            compiler constant)

E.7 Insert / Replace Text

      Toggle Modes   <CTRL><SHIFT> I
      Insert Line   <SHIFT><INSERT>

E.8 Restore Altered Line

      Restore Line   don't move cursor, <CTRL><SHIFT> U
      Recall Line   don't move cursor, <CTRL><SHIFT> P

E.9 Text Blocks

      Load Block   position cursor, <SHIFT><DELETE>
                        until done
      Paste Block   position cursor, <CTRL><SHIFT> P

E.10 Searches / Substitutions

      Find String   <CTRL><SHIFT> F, enter string
      Substitute   <CTRL><SHIFT> S, enter new string,
                        <RETURN>, enter old string

E.11 Breaking & Combining Lines

      Break Line   position cursor, <CTRL><SHIFT> <RETURN>
      Combine Line   put cursor at front of second line,
                        <CTRL><SHIFT> <BACK S>

E.12 Leaving the Editor

      Leave Editor   <CTRL><SHIFT> M

Appendix H: "PRIMES" Benchmark

This is the benchmark test from September, 1981 BYTE
Magazine, pp. 180-198, as implemented in ACTION! Here
is a table of our times to compare with those in the
magazine:

Mode	Time
Compilation	≃.25 sec.
Display off	12.2 sec.
Display on	17.9 sec.

```
    DEFINE size = "8190",
           ON = "1",
           OFF = "0"

    BYTE ARRAY flags(size+1)

    CARD count, i, k, prime

    BYTE DISPLAY=$22F,
         iter,
         tick=20,
         tock=19

PROC Primes()
    DISPLAY = 0 ;comment this line to leave display on
    tick = 0
    tock=0
    FOR iter=1 TO 10
        DO
        count = 0
        ; turn flags on (non-zero)
        SetBlock(flags, size, ON)
        FOR i = 0 TO size
            DO
            IF flags(i) THEN
                prime = i+i+3
                ;PrintCE(prime)   ;Uncomment to print primes
                k = prime + i
                WHILE k <= size
                    DO
                    flags(k) = OFF
                    k ==+ prime
                    OD
                count ==+ 1
            FI
            OD
        OD
    i=tick+256*tock
    DISPLAY = $22 ;turn display back on
    PrintF("%U Primes done in %U ticks %E", count, i)
RETURN
```

Appendix G: Options Menu Summary
----

prompt	default	range

Display on?   Y   Y or N
     Controls the screen during compile & device I/O

Bell off?   N   Y or N
     Controls bell response.

Case insensitive?   N   Y or N
     Controls the compiler check for upper case key
     words in the language and the case distinction in
     variable names.

Trace on?   N   Y or N
     Controls compiler setup of programs so that the
     program, during execution, notes entry into any
     PROCedure or FUNCtion.

List on?   N   Y or N
     Controls compiler listing of program lines to
     screen during compile process.

Window size?   18   5 to 18
     Controls window 1 size. Window 1 and window 2,
     combined, use 23 lines.

Line size?   120   1 to 240
     Controls line length.

Left margin?   2   0 to 39
     Controls left margin in window; set as low as you
     find comfortable.

EOL character? $9B   any ATASCII character
     Change the End-Of-Line character to aid
     visualization of program.

```
PRINT "I=";I                    PrintF("I=%I%E", i)
                                       or
                                Print("I=")  PrintIE(i)

PRINT #3; B*3;                  PrintBD(3, b*3)

INPUT I                         Put('?) : i=InputI()
      Note the use of the optional colon (:) in the
      ACTION! example.  Colons are ignored by ACTION!
      and so may used as statement separators.

INPUT B$                        Put('?) : InputS(ba)

PUT #0,65                       Put('A)
                                   or
                                Put(65)
                                   or
                                Put($41)

GET #C,B                        b = GetD(c)

OPEN #1,4,0,"K:"                Open(1, "K:", 4, 0)

CLOSE #3                        Close(3)

NOTE #1,C,B                     Note (1, @c, @b)

POINT #1,C,B                    Point(1, c, b)

XIO 18,#6,0,0,"S:"              XIO(6,0,18,0,0,"S:")
                                   or see also the Fill
                                   library routine

B=PEEK( C )                     b = Peek(c)
                                   or, in better ACTION! form,
                                ba = c  :  b = ba^

POKE C,B                        Poke(c,b)
                                   or, in better ACTION! form,
                                ba = c : ba^ = b

GRAPHICS 8                      Graphics(8)

COLOR 3                         color = 3
                                   Note:  color is a system
                                   library variable and is
                                   predefined by ACTION!

DRAWTO C,D                      DrawTo(c,d)

LOCATE C,D,B                    b = Locate(c,d)

PLOT C,D                        Plot(c,d)
```

This   appendix   presents   several   BASIC   functions,
routines,   statements,   etc.   For   each   BASIC   example
given, a corresponding ACTION! example is also given.

In the BASIC examples given, no line numbers are shown
unless necessary for illustration purposes.   You should
assume the existence of appropriate line numbers in
most cases.

In the ACTION! examples shown,   assume the following
variable declarations:

        INT   i,j,k
        CARD c,d,e
        BYTE a,b
        BYTE ARRAY s,t,aa,ba
        CARD ARRAY ca,da,ea
        INT ARRAY ia,ja,ka

BASIC statements   ACTION! equivalents
------------------   -------------------

C = D+I*A   c = d + i * a

IF A<>Ø THEN B=1   IF a<>Ø THEN b=1 FI

10 IF A=Ø THEN 30   IF a<>Ø THEN
20 B=1 : C=A*2   b=1   c=a*2
30 REM   FI

10 IF A=Ø THEN B=1 GOTO 30   IF a=Ø THEN b=1
20 B=7   ELSE b=7
30 REM   FI

FOR I=1 TO 1ØØ ...   FOR i = 1 TO 1ØØ DO ...
        NEXT I   OD

PRINT "HELLO"   PrintE("HELLO")

PRINT "HELLO";   Print("HELLO")

PRINT #5;"HELLO"   PrintDE(5,"HELLO")

PRINT #5;"HELLO";   PrintD(5,"HELLO")

PRINT I   PrintIE(i)

```
POSITION C,D                    Position(c,d)

SETCOLOR 0,1,C                  SetColor(0,1,c)

GRAPHICS 24 : COLOR C :         Graphics(24) : color = c
  PLOT 200,150 :                Plot(200,150)
  DRAWTO 120,20 :               DrawTo(120,20
  POSITION 40,150 :             Fill(40,150)
  POKE 765,C :
  XIO 18,#6,0,0,"S:"

SOUND 0,121,10,6                Sound(0,121,10,6)

C = PADDLE( B )                 c = Paddle(b)
C = PTRIG( B )                  c = Ptrig(b)
C = STICK( B )                  c = Stick(b)
C = STRIG( B )                  c = Strig(b)

B$ = S$                         SCopy(ba, s)

B$ = S$(3,5)                    SCopyS(ba, s, 3, 5)

B$(3,5) = S$                    SAssign(ba, s, 3, 5)

B=INT(6*RND(0)) + 1             b = Rand(6) + 1

FOR C = 4000 TO 5000 :          Zero(4000, 1001)
  POKE C,0 : NEXT C

STOP                            Break()

B$ = STR$( I )                  StrI(i, ba)

I = VAL( S$ )                   i = ValI(s)
```